

DESIGN FOR THE
HOCKING VALLEY POWER PROJECT

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A design for the Hocking
Valley power project

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A DESIGN FOR THE HOCKING VALLEY POWER PROJECT.

A THESIS

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*approved
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Prof. of Elect. Eng.*

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DRAWINGS.

Plan View of Central Station.

Cross Section View of Central Station.

Plan and Cross Section Views of Substation.

Wiring Diagram of Central Station.

Wiring Diagram and Front Elevation of Switchboard,
for Substation.



A DESIGN FOR THE HOCKING VALLEY POWER PROJECT.

I INTRODUCTION.

1. Preliminary Survey:

In many respects the Hocking Valley district of southern Ohio, presents a very inviting field for central station development. This district extending from Columbus, Ohio, and following the Hocking river to Parkersburg, W. Virginia, covers a country, the location of whose natural resources and industrial centers are particularly adaptable to the economical generation and distribution of electrical energy.

The extensive coal fields located in the central section along the Hocking river, produce an excellent grade of fuel at a point where plenty of water for cooling purposes is available and provide an ideal site for a central station. The fact that the power station may be located at the mine insures a practically unlimited supply of fuel at all times, with a minimum of handling, and at a low cost (even the commercially unmarketable grades may be used with properly designed furnaces), leading to the production of power at a minimum cost.

578

1013

Originally, the project was developed on the basis of supplying the demand for energy created by the Electric railway project which is under construction at the present time between Columbus and Parkersburg, but this has been extended to include the lighting and power requirements of the cities traversed by, and adjacent to the railway line. Among the important cities in this region are: Columbus, Lancaster, Logan, Athens, and Marietta in Ohio and Parkersburg in W. Virginia. The map, Fig.1 shows the principal cities in this region and their location.

These cities are prosperous manufacturing and mining centers, whose industrial establishments are now equipped for the use of electrical power and who may be considered as available customers for a low rate power. Similarly, the central station lighting and power companies now operating in this territory may also be considered as available. The advent of cheap power has a marked influence in the development of a community and is an important factor in the load building for the central station, insuring a constantly growing demand for power.

2. General Plan of Project:

The general plan to be followed is to locate the

generating station at a suitable point adjacent to the coal mines or to the source of energy as in the case of the hydro-electric development, and to distribute the current to the cities and traction system by high tension transmission lines.

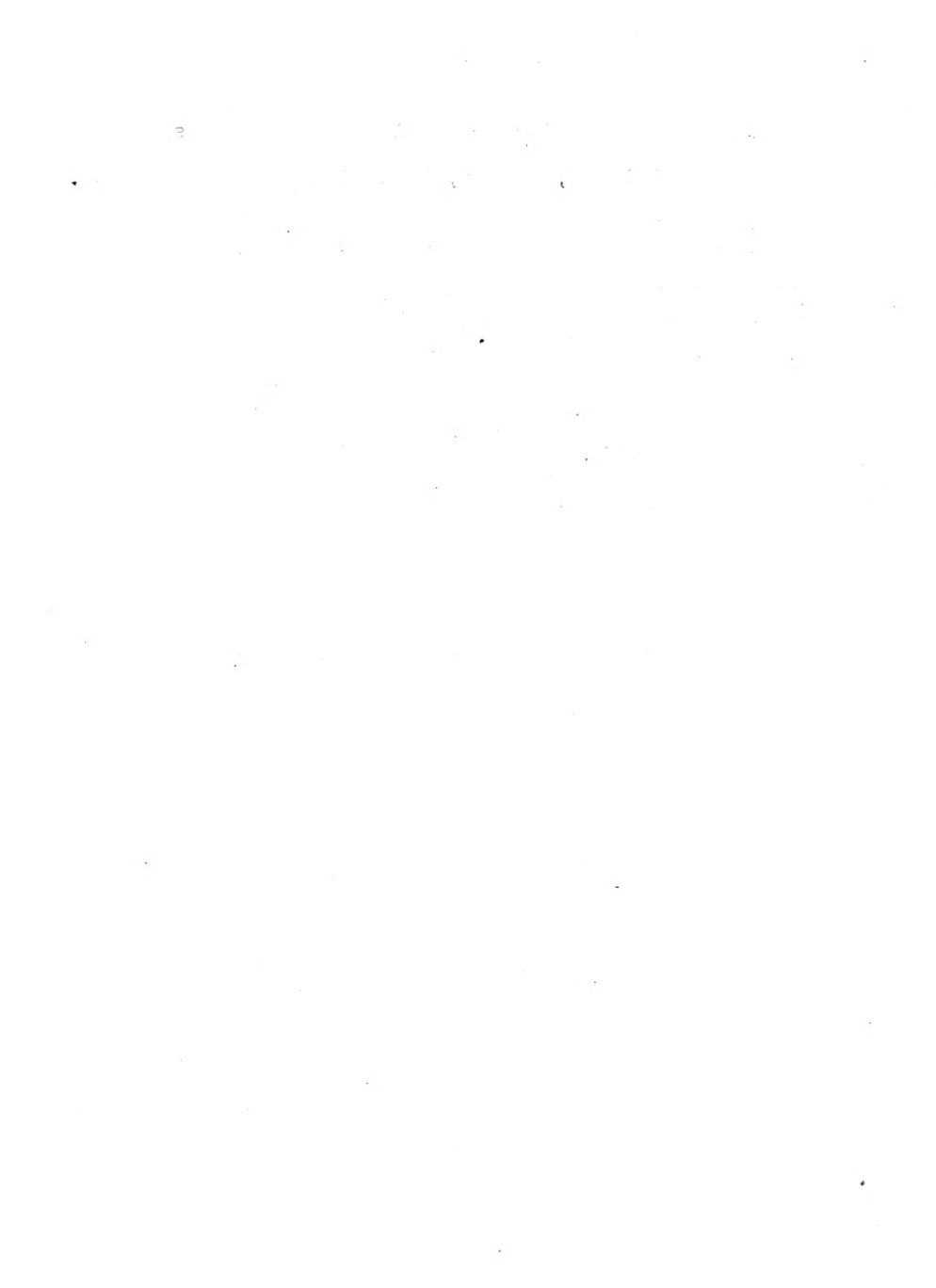
3- Scope of the Work.

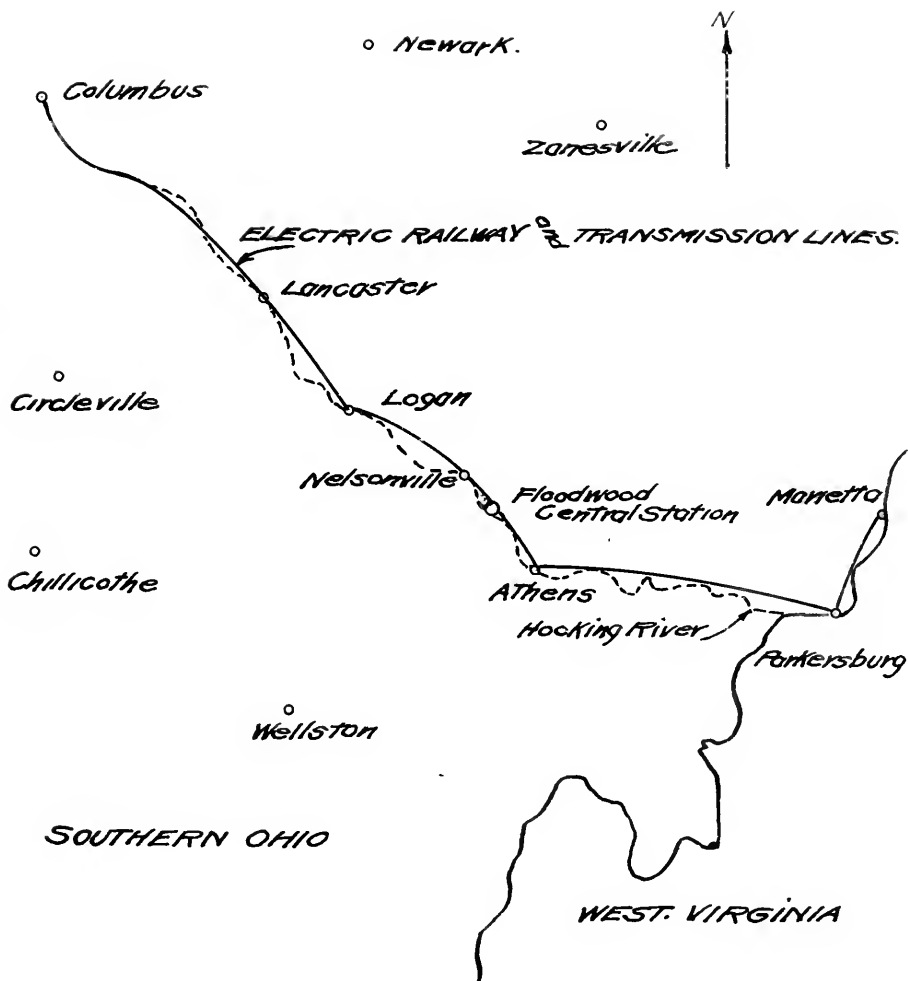
In carrying out the design for the subject of this thesis, the authors have attempted to provide an assemblage of machines and devices entering into a complete system for the generation and distribution of electrical energy. The work has been divided into three parts, as follows: the design of a central station, the design of a typical sub-station and the design of a transmission line.

Calculations have been made to cover the principle items and most of the auxiliary appliances required. Selection was then made from the manufacturers' standard line of apparatus and their recommendations given due consideration in the final determination of the auxiliaries. Particular attention has been given to the arrangement of the apparatus and in this respect we have endeavored to correlate the various elements in such a

manner that the chief characteristics of the design may be; Flexibility, Safety, Reliability and Simplicity.

With the drawings has been included detail specifications for the principle apparatus in the central station equipment.





MAP OF
HOCKING VALLEY POWER PROJECT
FIG-1

A DESIGN FOR THE HOCKING VALLEY POWER PROJECT.

II - GENERAL DESCRIPTION OF PROJECT.

4- Outline:

The project will consist of building a central power station to be located at Floodwood, Ohio, together with the electric railway and transformer substations, and transmission lines necessary for the generation and distribution of electrical energy to the cities and electrical railways adjacent to the Hocking river.

The map, Fig. 1 shows the general scheme of the project and its location.

In the table given below is a list of the principle cities, their population and distance from the central station.

City.	Pop.	Distance from C.S.
Athens.	5,500	6.5 miles.
Columbus.	181,500	59.
Logan.	4,850	13.
Lancaster.	13,100	27.5
Marietta.	12,950	47.
Nelsonville.	6,100	3.
Parkersburg.	17,850	37.

The central station will be designed for a maximum load of 15,000 KW., the rated capacity will be 16,000 KW. The 25 cycle current will be generated at 2300 v., then stepped up to 70,000 volts for transmission to the various sub-stations. At the sub-stations, the voltage will be reduced to 2,300 v. for distribution for lighting and power purposes, or converted to 600 volts D.C. for electric railway use.

The transmission lines will follow the route of the Electric Railway in as far as possible and be in duplicate, with the exception of that to Columbus on which, one additional three phase circuit will be run, to individually take care of the 2,000 KW. commercial load for Columbus.

The sub-stations for the most part are to be combined lighting and railway sub-stations and conveniently located to the load centers.

5- Load Curve;

The load curve Fig. 2 has been based on the possibility of supplying energy for lighting and power purposes to the cities indicated in the foregoing article, together with the energy for the electric railway system. The



heavy line curve represents the total load, and the dotted curve, the railway load.

The general characteristics of the load are as follows;
From 10 P.M. to 5 A. M. average load 3,000 KW. - 7 hours.

From 5 A.M. the curve rises rapidly reaching a peak of 12,000 KW. at 7.45 A.M., then falling back to 8,000 KW. at 10 A.M.

From 10 A.M. there is an average load of 8,500 KW. lasting to 4 P.M.

From 4 P.M. the curve rises to the evening peak of 15,000 KW. occurring at 7 and falling to 4,000 KW. at 10 P.M.

Daily load factor 60%

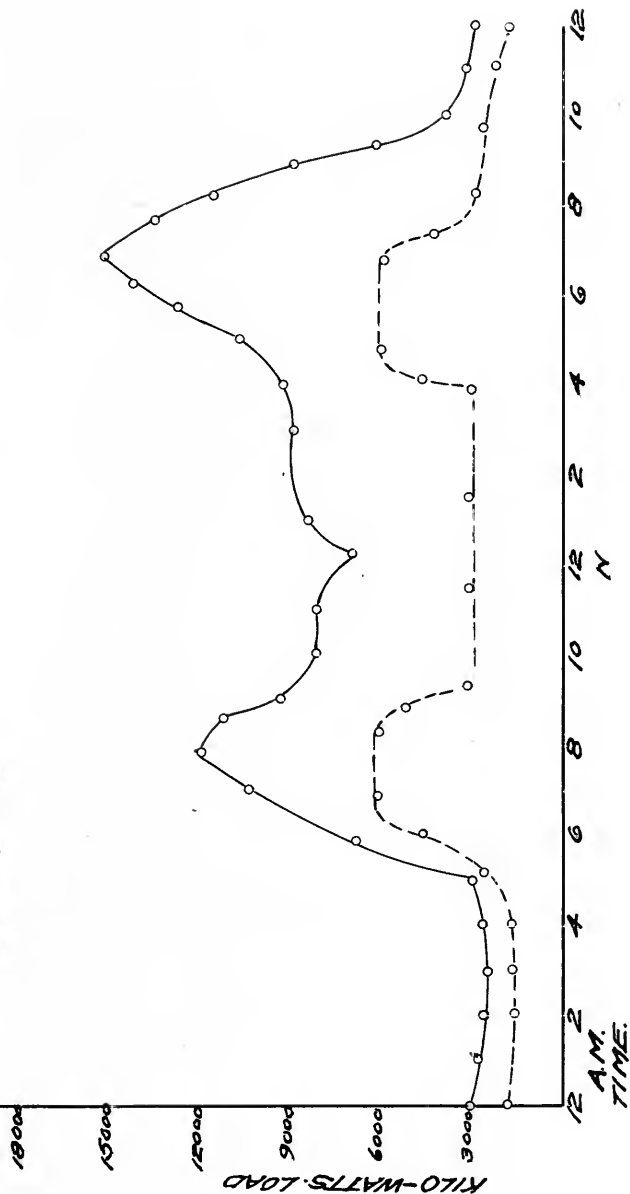
The power factor for this class of service has been taken as 85 % (average).



LOAD CURVES

FLOODWOOD POWER STATION.

— TOTAL LOAD.
 --- RAILWAY LOAD.



A DESIGN FOR THE HOCKING VALLEY POWER PROJECT.

III DESIGN OF CENTRAL STATION.

6- Location.

Floodwood, Athens County, Ohio., has been selected as the most suitable location for the power station. This location has the advantages of: Having fuel and water close at hand. Accessible to the Hocking Valley Railroad for the purpose of transporting building material and heavy machinery. Accesible to the Electric Railway in that the local sub-station may be located in the power station. It is centrally located with respect to the load. The local labor market is capable of supplying sufficient working forces for erecting and operating the station.

7- Selection of Units.

In selecting the units it was considered desirable to use similar machines if possible and have one reverse unit without having to provide excessive capacity and keeping within the limits of economical operation of the individual machines.

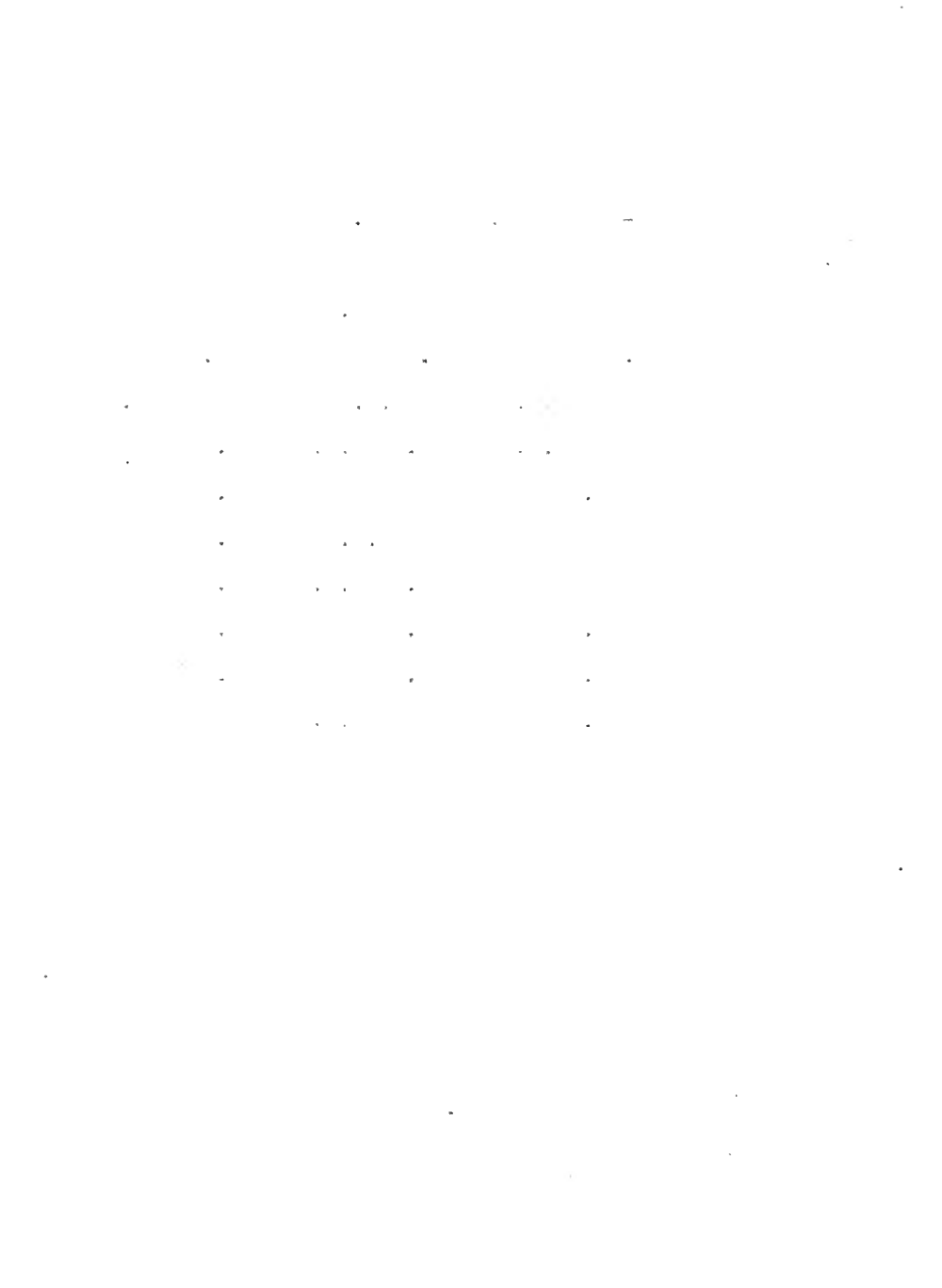


Several combinations were worked out in turn to this end and the one proving most satisfactory was the employment of 4- 4,000 KW. Machines. This combination gives operating conditions as follows:

Operating Conditions.

Units Operating.	Period.		Time.
1	10 P.M. to	5 A.M.	7 Hours.
2	5 A.M. to	6.15 A.M.	1.15
3	6.15 to	10 A.M.	3.45
2	10 to	4 P.M.	6.
3	4 to	5.30 P.M.	1.30
4	5.30 to	8.15 P.M.	2.45
3	8.15 to	9.00	0.45
2	9.00 to	10 P.M.	1.00

With one machine out of service the remaining three could carry the maximum peak with an overload of 125 %; the equivalent duration of this overload being 1-1/2 hours, which is within the standard rating of the machines. This arrangement allows flexibility in the operating schedule permitting the reserve unit to be interchanged on alternate days as desired.



8- The Building.

The exterior of the power station is to be of neat appearance and of simple architectural design. It will be constructed of heavy structural steel and brick, faced with pressed brick and litholite trimmings, and fireproof through out, both floors and roof being of concrete. The roof is supported by a structural steel truss of the self-supporting type and the whole superstructure carried on concrete footings driven down to solid rock.

A liberal monitor with glass sides and roof extends the length of the building and in connection with end windows provides a well distributed light, and good ventilation.

The building will be rectangular in shape, fronting the river bank for a distance of 194'. It is divided into three sections, a boiler room, 104' in width, a turbine room 50' in width, and a switching room 20' in width, the dividing walls running parallel to the river bank. Heavy fire doors are to be provided for all openings in these walls, in order to effectively isolate the sections when desired.



In arranging the apparatus, the unit system has been adopted and all the auxiliaries required for each unit have been grouped around the generating unit and of a sufficient capacity for that one only. All of the auxiliaries including the boiler feed pumps have been placed in the turbine room basement. The boiler room contains only the boilers, feed water heater, and the necessary piping etc.

All the electrical apparatus has been grouped together and is to be installed in a separate section adjoining the turbine room, isolated from noise and dirt of the latter and free of liability of damage by accidents to the turbine room machinery. This section is three stories in height and the operating gallery is located on the second floor.

A twenty-five ton electric traveling crane is arranged to serve all the machinery in the turbine room, and in addition a switch spur has been extended from the coal track into one end of the turbine room to facilitate the handling of heavy machinery.



9- Boiler Room.

(a) Boilers:

The sixteen (16) 500 H.P. Babcock & Wilcox boilers are arranged in two rows facing each other, with a 20' firing aisle between. They are grouped in batteries of two each, making 8 sections of 1,000 H.P. or a total of 8,000 boiler H.P.

Each boiler will be equipped with B. & W. traveling chain grates and superheaters, and under normal conditions will operate as shown: Pressure, 200# per sq. in (gauge); Superheat, 150° Fhr. above the temperature, due to the pressure carried; Feed water temperature, 210°F.

Both boilers of each battery are connected to a common 6" lead by 4" expansion bends and angle valves placed directly above the boiler. This 6" lead is then connected to a 14" main header running parallel to the boiler room. This arrangement allows each boiler to be individually disconnected for the purpose of washing or repairing.

The stockers, fuel and ash conveyers and all boiler appliances are to be driven by induction motors of the dust-proof type.



(b) Steam Boilers.

The steam headers have been installed singly throughout, and for that reason are to be of the best grade of wrought steel pipe, connected by cast steel fittings, lagged with a good grade of non-conducting material, and installed rigidly on supports properly constructed to take care of expansion.

The main 14" steam header runs along the wall on one side of the boiler room; to it are connected the 6" boiler leads and the 8" turbine feeders. Valves on each of the pipe lines connecting to the main header are placed so that they may be operated from the floor.

Two secondary steam headers connected to the main header have been provided to supply the auxiliary apparatus. The first, an 8" line, runs along the wall in the turbine room basement and supplies the feed water pumps, the turbo-exciter set and the dry vacuum pumps; the other runs along the basement ceiling and directly under the turbines and supplies the circulating and hot well pumps.

(c) Coal and Ash Apparatus.

In this installation the fuel problem has been simplified, in that the station is located adjacent



to the coal mine and large coal storage bunkers will not be necessary. A standard bucket ash and coal conveyor system has been installed in duplicate, one for each row of boilers, and will operate as follows: The coal will be brought from the mine in gondola cars and dumped into pits outside the boiler house, the conveyor buckets then elevate and carry the coal to the various bunkers above the boilers, distributing it as desired and continuing to the basement passes over a runway, directly under the ash and fine coal chutes. These chutes are fitted up with dampers or valves so either may be collected in the buckets and the ash carried to a bunker over the track or the fine coal returned to the coal bunkers.

There are four coal bunkers on each side of the boiler room each serving two boilers and the down spout, feeds two boilers and leads the coal to the hopper of the traveling grates. The coal bunkers are to be constructed of steel plate and angle irons, supported by steel beams and fastened to the roof truss, and of sufficient capacity to hold ten days coal supply.

(d) Chimneys:

10000

10000

There will be two brick lined steel chimneys, 14" in diameter and 170' in height, centrally situated behind each row of boilers. They will be securely anchored to heavy concrete foundations and provided with plate curbing where the stack runs through the roof.

The main breeching is 10' X 12.5' and is constructed of #10 sheet iron stiffened with angle iron braces, and supported from the roof truss.

(e) Feed Water Piping.

The feed water piping is in duplicate and so arranged that either of two pumps may supply water from the feed water heater or from the circulating water tunnel to two separate feed water piping systems.

The feed water headers are located under and to each end of the boilers; one header is connected to each end of a battery, and a short pipe run overhead connecting these ends; the other header is connected into this short pipe midway between the boilers.

With this arrangement both boilers can be supplied from either one or both piping systems at the same time, or each boiler can be supplied separately from either system.



10- Turbine Room.

(a) General.

The turbine room is 194' in length and 50' in width and contains all the machinery of the station.

The turbo-generator units, rotary converters and motor-exciter set occupy the main floor, and all the auxiliary apparatus has been placed in the open basement, and grouped about the units they are to serve.

As previously stated, the unit system has been followed, and a complete set of auxiliaries provided for each generating unit, and of a sufficient capacity for that one only. For a complete description of the principle apparatus of the power station equipment see drawings and detailed specifications.

(b) Turbo Units.

There will be 4- 4,000 K.W. Curtis-General Electric generating sets, operating at 12,000 RPM. and giving a current of 30,000 alternations per minute.

The turbines will be of the type known as the multi-velocity and multi-pressure stage, and when operating under most efficient conditions will use 14[#] of steam per KW. Hr. The alternators will be General Electric make, delta connected, and are to generate

1733

current at a potential of 2,300 volts, and at a rate of 1,000 amps. per phase.

The exciter units will each be of sufficient capacity to take care of the field current for the four machines when operating at full load. One set will consist of a 200 K.W. shunt wound generator operated by an induction motor, and the other a 200KW. shunt generator direct connected to a Curtis turbine. Both generators to be wound for 125 volts.

The converters are to be 500 KW, 25 cycle, six phase machines of the railway type. Each will deliver a direct current of 83.5 amps. at 600 volts.

Each condensing equipment will consist of the following items:

One Wheeler dry tube condenser having 10,000 sq. ft. of cooling surface. Placed under the base of the turbine and between turbine foundations.

One Algerger-Curtis 20" tri-propeller circulating water pump of the double suction type. This pump will have a capacity of 4,500 gallons per minute.

One 4" two stage hot well pump driven by a Terry turbine. Capacity 200 gallons per minute.



One dry vacuum pump operated by engine.

There will be two feed water pumps of the volute type, each capable of furnishing water for the entire boiler equipment, and driven by a steam turbine mounted on the same bedplate. One house pump of the Deane piston type will be required.

11- Switch Room.

(a) General.

The switch-geat and transformer galleries are to form the east section of Floodwood Station. This section is to consist of three floors; the first to be occupied by the power transformers, the second by the operating board, the oil switches and disconnects, the third by the lightening arresters and high tension bus bars.

The low tension cables will pass thru the wall from the generator room to the power transformers, where the voltage is raised from 2,300 to 70,000. From the transformers, the high tension conductors pass thru the ceiling to the second floor. Here the current passes thru the disconnects to the H oil switches and thence to the high tension bus bars on the third floor.

(b) Specifications for Main Switchboard and Switchgear for Floodwood Station.

- 1- Panels to be of blue Vermont Marble.
- 2- Instruments to have marine finish; to be dead be at and protected from stray fields produced by adjacent connections or bus bars.
- 3- Oil switches shall have kilowatt rupturing capacity based on the ultimate installation of generators as heretofore stated in these specifications. The switches shall withstand for one minute a potential test between the contacts and the frame, of at least twice the rated voltage of the circuit.
- 4- All switches shall be of such capacities as to carry the one or two hour overload rating of the circuits to which they are connected, without undue temperature rise and shall be properly designed for the service they are intended.
- 5- Connection bars and wires shall be of sufficient cross section so that with a maximum load the temperature rise at no point will exceed 40°C above that of the surrounding air.

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22 23

Special.

Bus Bars L. T.

Of copper. Shall be located on the east wall of generator room in concrete compartments with soap stone barriers. To be mounted porcelain insulators.

Bus Bars H. T.

Of copper. Shall be located on the west wall of lightening arrester galleries. Concrete compartments with soapstone barriers. To be mounted on porcelain insulators.

Ground Connections.

Ground wire to be soldered and riveted to copper plates 3/16" thick and 5' square. Plate to be buried in powdered charcoal at a depth of 10'.

Switchboard.

To be of blue Vermont marble, of the bench type and set in concrete. Each panel to be illuminated by three cp.-125 volt lamps.

Switches, Oil, H. T.

To be of 70,000 volt H₂ type. Remote control. Over load release. Open and closed switch to be indicated by green and red bulls-eye lights respectively, located on the switchboard. Switches to be placed on the



second floor of the electrical gallery.

Switches, oil, L. T.

To be of 2,300 volt K type. Remote control. Over-load release, except in case of generator switches. Generator switch to automatically indicate over-load on the generator bulls-eye light on the switchboard.

Switches, Knife, Hand Operated.

H.T. disconnecting switches to be S.P.S.T. type, for 50 amps. at 70,000 volts. L. T. disconnecting switches to be of the same type, for 750 amps. at 2,300 volts. Switch in each phase. Switches to be located in sight of each oil switch. Switches to be operated by hand by long-handled hooks.

Wall Bushing, H.T.

Shall be the 70,000 volt porcelain soapstone type as manufactured by R. Thomas Sons Co.

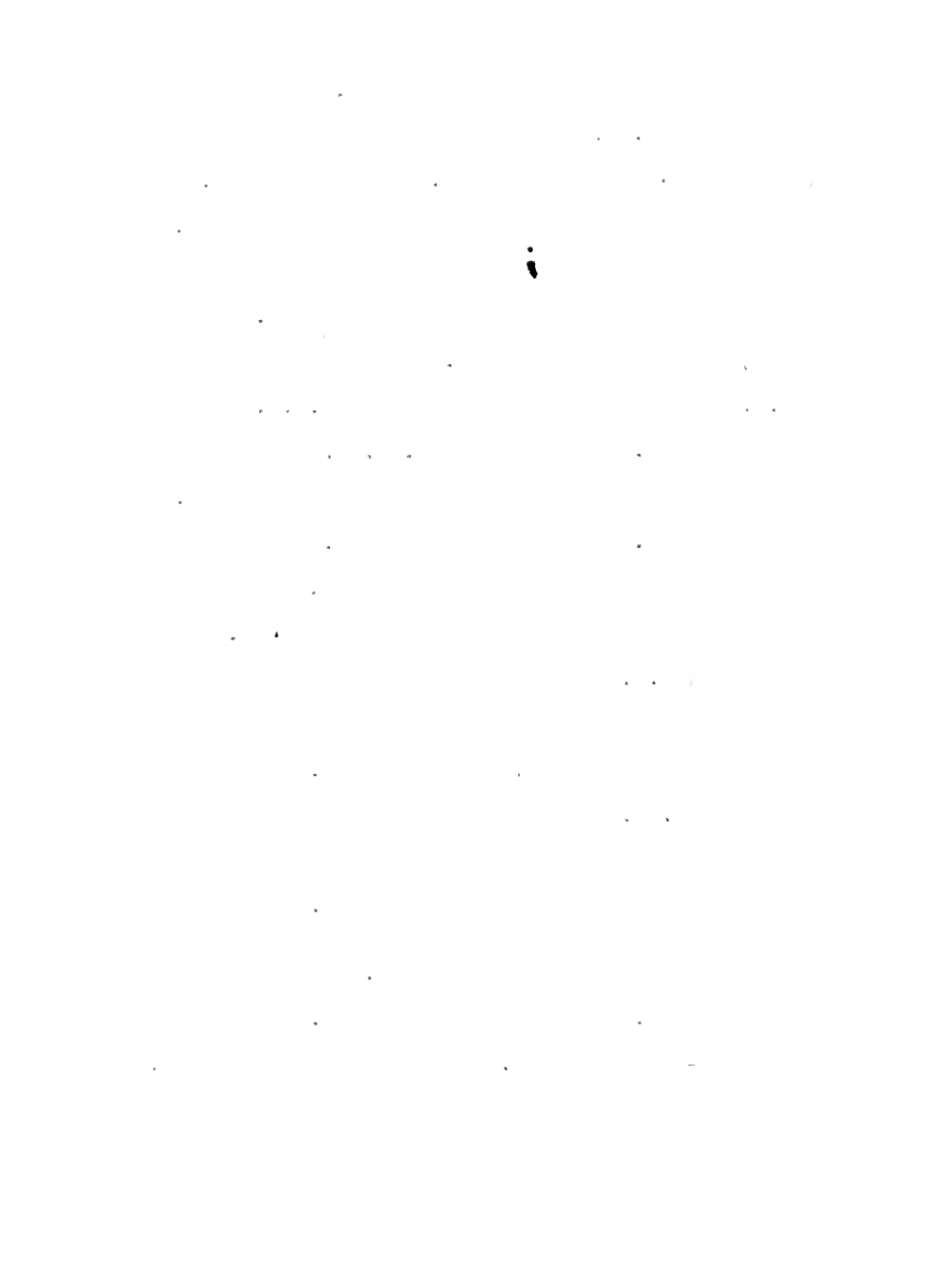
Wall Bushing L. T.

Shall be the 2,300 volt porcelain-soap-stone type as manufactured by the same Company.

Instruments For Each Generator Panel.

3 - 750 Amp. Ammeters- Westinghouse.

1 - 60 - 100 - 60% P.F. Indicator Westinghouse.



- 1- Polyphase induction recording wattmeter.
- 1- 250 amp. D. C. Weston Ammeter.
- 1- 4,000 KW. indicating wattmeter.
- 1- 125 volt, Type C, Form G, controlling switch,
for electrically operated field rheostat.
- 1- 6 point synchronizing receptacle and plug.
- 2- Lamp sockets, cat. No. 50798 for bulls-eye lamps.
- 1- Red bulls-eye lamp.
- 1- Green bulls-eye lamp.
- 1- 8 point voltmeter receptacle with plug.
- 5- S.P.D.T. controlling switches for H_3 and K_2
oil switches.
- 1- D.T.D.P, 25 amp., 125 volt, Type C, Form G,
engine governor control switch.

Instruments Common to All Generator Panels.

- 1- Westinghouse voltmeter (0-2300)
- 1- Westinghouse 25 cycle frequency meter.
- 1- Westinghouse synchronous indicator.

Instruments for Exciter Panels.

- 1- 1600 amp. Weston ammeter D.C.
- 2- Westinghouse ground detectors.



1- D.P.D.T. 125 volt, Type C, Form G, controlling switch for turbine governor.

2- D.P.D.T. 125 volt, Type C, Form G, controlling switch for electrically operated field rheostats.

2- S.P.D.T. switches to control G.E.; D. C. circuit breaker.

1- S.P.D.T. switch to control three K₂ interlocked oil switches which control induction motor prime mover.

1- S.P.D.T. switch to control equalizer switch.

1- D.P.D.T. switch for voltmeter.

2- 6 point ground detector receptacles.

Instrument transformers for each Generator Panel.

6- Type S, Form E, current transformers, ratio 300.

1-

2- Potential transformers, Ratio 2300/ 110, 150 watts.

Lightening Arresters.

To be combination of horn gap and electrolytic.

Grounded as specified under "Ground Connections".

Wiring of Power and Control Circuits.

Shall be in accordance with city ordinances and



rules of the "National Board of Underwriters".
Wires to be clamped so that they will not be
dislodged should any joint or terminal come
loose. The ends of each conductor shall be
tagged with numbered tags, fastened with
brass wire.



14- Specifications.

In the following pages will be found detailed specifications for the principle items of the Central Station equipment as given in the table below.

Specifications for	Page.
Turbo Generators,-----	30
Boilers,-----	44
Feed water heater,-----	53
Condensing equipment,-----	58
Boiler Pumps,-----	71



SPECIFICATIONS FOR 4,000 K.W. GENERATORS
FOR
FLOODWOOD POWER STATIONS.

General Description;

The general design to be in accordance with the outline drawing accompanying these specifications. The turbine to be of the type known as the multi-velocity and multi-expansion impulse and adapted for driving a direct connected generator, running at 1,200 RPM. and giving 3,000 alternations per minute.

The turbine together with the generator to be mounted on a continuous bedplate, provided with suitable supports for turbine, generator, generator bearings, etc. All revolving parts to be accurately balanced so as to run smoothly and without undue vibration or noise.

Material and Workmanship;

The various materials entering into the construction of the turbine to be of first class quality and in kind conforming to the most approved practice as regards each individual part of the machine. The workmanship to be of high grade character in every detail.



Capacity:

To develop 4,000 K.W. when operating at 1200 RPM., with dry saturated steam of 200 pounds pressure per sq. inch at the throttle and with a pressure in the exhaust pipe of 2" of mercury absolute at the turbine exhaust outlet. The turbine will be capable of operating in an efficient and serviceable manner under all fluctuations of load within its specified capacity, and with any quality of steam between saturation and 175 superheat.

Parallel Operation:

Having no reciprocating parts the turning effort being practically uniform during one revolution, and the rotating parts having considerable mass and velocity the angular speed of the turbine will be substantially constant, insuring the successful operation of alternating current generators in parallel which is hereby guaranteed.

Economy:

The quantities of steam hereinafter given, include as steam used or consumed by the turbine and all leakages or losses in the turbine does not include steam consumed by the auxiliaries.

It is understood that the regular conditions under

which these turbines are to operate will be as follows: 200# steam pressure, 2" of mercury absolute back pressure and 150° Fhr. of superheat.

The steam consumption will not exceed the following quantities when operating at 1,200 RPM.; with steam superheated 150° degrees F. above the temperature of saturated steam, measured at the throttle at a pressure in the exhaust pipe of 2" of mercury absolute.

Full Load (4,000 KW.)	14lbs. steam per K.W.H.
(3,000 ")	
3/4 " "	14.7 " " " "
1/2 " (2,000 ")	16.1 " " " "
1-1/4 " (5,000 ")	14.5 " " " "

Overload:

The turbine is to be provided with a secondary governor valve by means of which 50% overload may be developed when operating without condenser, during which time the turbine will work smoothly and properly with out undue wear.

The valve is to be automatically operated by a suitable mechanism in connection with the governor and arranged to open when the load exceeds the amount



that the turbine can carry when operating normally. It will similarly operate when the turbine is unable to normally carry the load and will automatically return to its seat then the excess capacity of the turbine is no longer required.

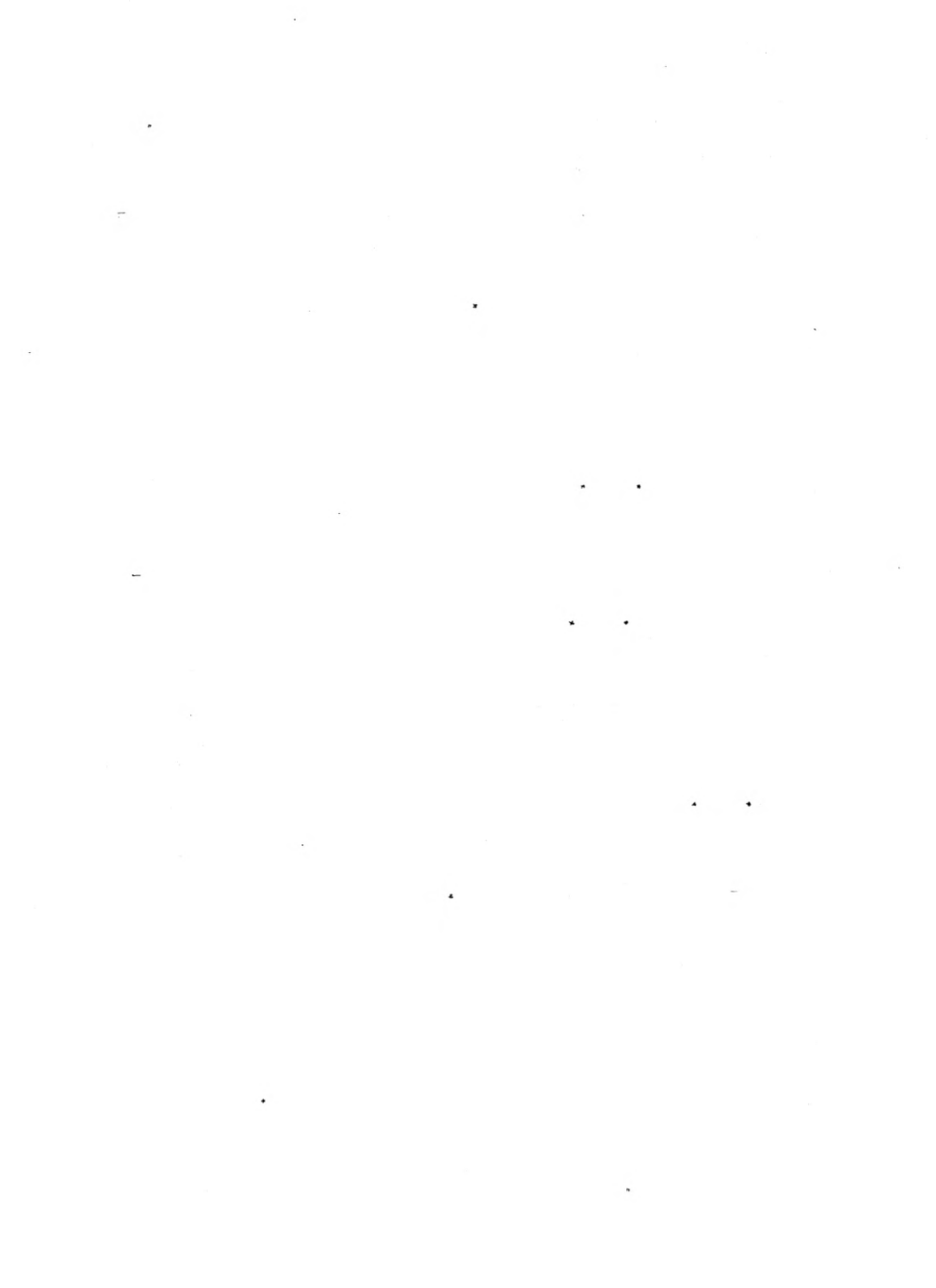
Cylinders:

To be of close grained cast iron and designed so that the tensile stress shall at no time exceed 2,000 # per sq. in. The single pressure sections of the turbine to be so designed that the stresses shall not exceed the above when subjected to a steam pressure of 225# sq. in.

The low pressure sections of the cylinders, when the normal stresses are usually less than above, to be designed so that the stresses shall not exceed 2,000# per sq. in. when subjected to the highest pressure due to operation under the before mentioned overload, or for non-condensing operation.

Glands:

Suitable glands or packing to be provided which will effectually prevent leakage where the turbine shaft passes thru the ends of the cylinder. These glands to be water sealed, no other oil or lubricant being necessary. No oil used in the turbine will be



able to find its way into cylinder thru these glands.

Turbine Blades:

To be of suitable material of the best mechanical construction and of form and dimensions most conducive to high economy.

Main Bearings:

To consist of heavy cast iron shells with babbit metal and to have ample surface so as to run cool and with our undue wear. The outer surface of the cast steel shells to be spherical, fitting in a corresponding concave seat to permit self aligning of the bearings. The bearings to be conveniently adjustable for taking up wear and arranged so that they may be readily taken off the turbine without first removing the turbine shaft. The turbine bearings will be mounted on extended portions of the turbine cylinder and the generator bearings on massive cast iron bolted to the bedplate.

Bedplate:

A suitable bedplate with planed supports or bearing pads for turbine, generator, etc., is to be provided. To be made of cast iron of box pattern heavily ribbed and of sufficient depth and strength to secure rigidity of the turbine.



Shaft:

To be of best quality of open hearth steel;
to have mounted thereon suitable cast steel rings for carrying the turbine blades, these castings to show the following physical characteristics in a standard test specimen 2" long and 1/2" in diameter.

Tensile strength not less than 65,000 pounds.

Elastic Limit	"	"	"	30,000 "
---------------	---	---	---	----------

Elongation	"	"	"	15%
------------	---	---	---	-----

When operating at maximum load, the stresses in the shaft due to the combined twisting and bending moments shall not exceed 9,000 # per sq. in.

Governor:

A suitable and sensitive governor to be provided for controlling the speed by varying the admission of steam; to be driven directly from the turbine by means of positive gearing. When the turbine is operating normally, the differences between the speed at friction load and the speed at full load will not exceed 3 % of the average speed, and the governor will be certain and positive in its operation. The variation in speed may be greater than that specified above ,should the character of the load of the turbine be such as to render

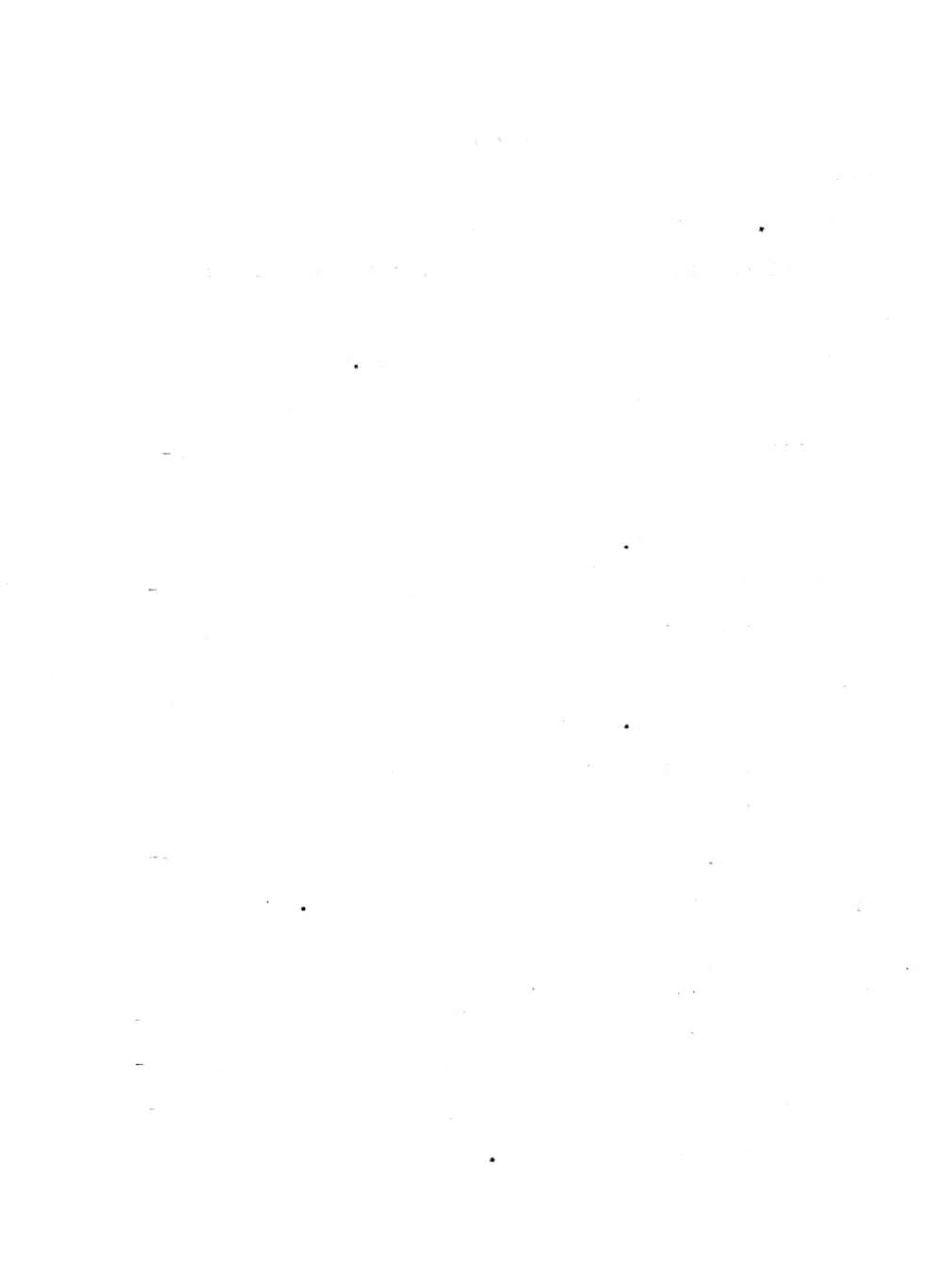


desirable a greater variation, such for example as the operation of alternating current generators in parallel. In this case the generator will be so proportioned that there will be no tendency for the load to surge between one turbine and another with which it may be connected in parallel.

The Company is to signify when accepting these specifications, which regulation will be more desirable for the particular purpose for which he intends to use the turbine. Means to be provided whereby the tension of the governor springs may be varied in either direction while the turbine is running, without in any way disturbing the operation otherwise than making the desired change. Necessary apparatus on the turbine to be provided to enable the operator to control the distribution of the load between the turbines from a common point. Connections to such apparatus and central control to be provided by the Company.

Lubrication:

The lubrication of all main bearings to be affected by a continuous circulation of oil supplied by a system of delivery and drain pipe, and a suitable reservoir located in the bedplate.



A suitable oil pump of simple and durable construction to be furnished and a means of driving the same by the turbine. An oil cooling coil to be allowed for, arranged within a suitable water chamber thru which the oil will circulate. The water chamber to be fitted up with suitable water connections. All necessary piping for the above purposes will be attached and fitted to the turbine in a first class workmanlike manner.

All oil piping above the floor level and in sight to be of brass or copper with polished brass fittings.

In addition to the above, will be furnished a full complement of small oil cups for the governor gear, etc. There will be no means by which it will be possible for oil to enter any of the steam chambers of the turbine and thereby come in contact with the exhaust steam.

Throttle Valve:

A suitable throttle valve to be provided, equipped with a small by-pass for warming up purposes.

Governor Valve:

The governor valve for controlling the admission of steam to be of the balanced poppet valve type, made of



cast iron and enclosed within a suitable steam chest. To be operated by the governor by means of a suitable mechanism.

Safety Stop:

A quick operating throttle, distinct from that referred to is to be provided, which in combination with separate auxiliary governor, will automatically close it self, should the turbine speed exceed the safe limit. Means to be provided for operating this safety stop by hand from a point close in proximity to the turbine.

Inspection:

The Company, or its representatives, are to be at liberty to inspect the work at any reasonable time during the construction.

Lifting Gear, Tools, etc.;

A complete set of wrenches to be furnished to fit all nuts. Also all necessary eye bolts for handling the various parts, as well as suitable lifting yokes and gear for removing the turbine shafts.

Painting:

The work is to be of high finish throughout and all parts that are not polished will receive two coats of

filler rubbed down smooth and one coat of flat paint before shipment. Any further painting to be done by the Company after erection.

TURBO ALTERNATOR.

General Description:

This alternating current generator will have a rotating field and will be of turbo type. There will be four poles and the frequency will be 3,000 alternations per minute (25 cycles per second) at a normal speed of 750 R.P.M. It will deliver 3 phase current at 2300 volts.

Generator to be of the enclosed type and to operate without undue noise or vibration.

General Construction:

The rotating part of the field must be built of high grade steel and will be mounted upon a forged steel shaft. This rotating part will form the field of the machine and will carry the field windings, which will be substantially supported against displacement vibration and centrifugal force. Means will be established for dissipating heat generated in the field windings.

The weight of the electrically and magnetically inactive material will be reduced to a minimum in

order that the weight on the bearings may be decreased. The external frame will be designed to allow access to the stationary armature windings.

Material and Workmanship:

To be of first class throughout, of a nature best suited to the requirements of the various parts and to be complete and sufficient in every detail.

Normal Full Load Rating:

The normal rating of this generator will be 1,000 amperes at 2,300 volts and 100 % power factor.

The normal rated out put therefore will be 4,000 Kilowatts.

Efficiency:

The efficiencies are based on the I^2R losses in the armature and field coils and armature iron losses. These losses are determined separately at the rated current and voltage and 100 % power factor, the efficiency will be not less than 95.5 % at half load; 96.7% at three-quarters load; 97.5 % at full load and 97.8 % at one and one-quarter load.

Excitation:

The generator will be separately excited. The field



will require approximately 100 amperes at 125 volts when the generator delivers its normal rated current at normal voltage and 100 % power factor. At maximum load, the exciting current will increase to 125 to 145 amperes, depending on the adjustment of the load.

Collector:

The collector will be of ample size for the maximum current to be carried. The brushes will be of carbon and there will be five brushes per collector ring.

Armature:

The armature will be of the slotted drum type. The core will be built of laminated steel of high magnetic quality. The laminations will be supported by a cast iron yoke or frame and dovetailed accurately thereto. The laminated core thus built up will be held firmly in place between two end plates. The armature winding will consist of cable wound coils, formed and insulated before being placed in the slots. The coils will be held in the slots by overhanging tips of teeth.

The insulation of the armature conductors will



consist of sheet material of high insulating quality, applied in overhanging layers. This will be held in place by tape and the whole treated with moisture proof or oil-proof compound. After completion, the insulation of the armature winding from the core will be subjected to a momentary puncture test of 9,000 volts alternating E.M.F.

Field:

The field poles will be made of steel. The steel pole pieces and the field winding will be so proportioned as to reduce the armature reaction and self-induction to a low limit. The field coils will be wound with strip copper. The insulation of the field coils from the poles will consist of several layers of fibrous material and will be substantial and permanent. After completion the insulation of the coils from the poles will be subjected to a momentary puncture test of 1,000 volts alternating E.M.F.

Temperature:

The generator will deliver its normal rated current at normal voltage and 100 % power factor for 24 hours with a rate of temperature not exceeding 35 C in



any part; at the same voltage and power factor, but 25 % greater current, it will operate for 24 hours with a rise not exceeding 50 C; at the same voltage and power factor, but 50% greater current, it will operate for 3 hours, succeeding a full load run with a rise not exceeding 60 C. Temperature to be measured by a thermometer in accordance with A.I.E.E. rules.

Ventilation:

Throughout the armature spider, core and windings, large and open ventilating ducts will be provided. The design of the rotating parts will be such as to set up a forced circulation of air through these ventilating spaces. Similar ventilating spaces will be provided in the field coils, so that a free circulation of air may be maintained while the machine is in operation. The end of the windings of the armature will circulate freely among them, thus keeping the temperature very low.

Regulation:

The rise in voltage with full load (100% power factor) thrown off will not exceed 10% with a constant speed and a constant excitation.

SPECIFICATIONS FOR THE BOILERS AND SUPERHEATERS
FOR
FLOODWOOD POWER STATION.

1 - Conditions of Service:

The 16 - 500 HP. Babcock & Wilcox boilers are to be arranged in batteries of two each, in two rows facing each other on the first floor of the boiler room. These boilers are to be operated at 200 pounds pressure, and to furnish steam superheated 150° Fhr. above the temperature due to the pressure carried.

2 - Description:

Each boiler shall be composed of twenty-one sections or slabs, each section to be composed of 14 best lap welded charcoal iron boiler tubes made from the best knobbled hammered charcoal iron blooms, each tube to be 4" in diameter and 18' long, connected at the ends by a continuous staggered headers or uptakes and down takes, fastened there in by being expanded into bored holes.

Each header is to be formed of open hearth steel plate forged to shape and provided with hand-holes placed



opposite the end of each tube, of sufficient size to permit of cleaning, removal and renewal of a tube through the same. Each handhole will be provided with a forged steel cap fastened with wrought iron bolts, safety clamp and cap nut, all joints being made tight, metal to metal.

The several sections to be connected at each end to 3 - 42" steam drums and one end to be a mud drum, by lap-welded wrought iron tubes 4" diameter and suitable length expanded into holes.

The three steam and water drums shall be 42" diameter and 22' long, connected to the back headers by vertical tubes, and to be made of open hearth steel plate 9/16" thick. The longitudinal seams are to be butt strapped, seams strapped inside and out, secured by six rows of rivets; circular seams to be double riveted. All holes for the longitudinal seams to be punched 3/16" smaller than the diameter of the rivets to be used and drilled to full size after the shuts are rolled and assembled with butt straps. After drilling, the butt straps are to be removed, all burs cleaned off and the plates assembled, metal to metal, with parallel turned bolts fitting the holes before riveting. The transverse or round-about seams will be punched to the

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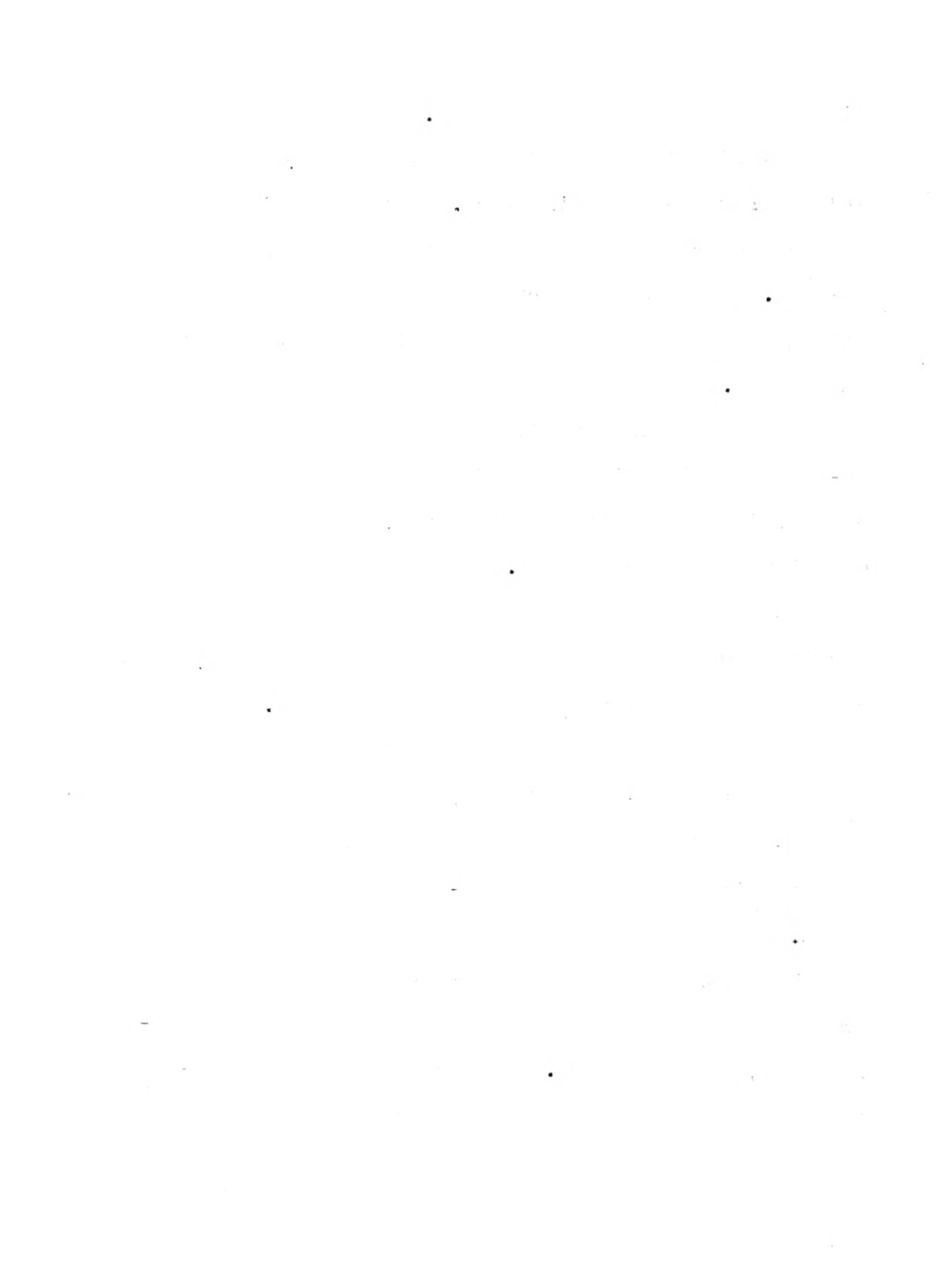
diameter of the rivet to be used.

All riveting to be done by hydraulic presses and the rivet held until black. The heads will be of open hearth steel plate 5/8" thick hydraulically flanged. The front and rear heads will be provided with manholes fitted with wrought iron manhole plates and guards.

Each drum will be fitted with a steam nozzle 5 - 1/2" opening with a 12" flange and a safety valve nozzle, 5" opening with a 11" flange, in a lathe and of a design to be agreed upon.

The cross boxes for connecting the sections (the sections) to the drums shall be hydraulic forgings, formed of open hearth steel plate 5/8" thick. To each drum will be fitted a steel spool piece having a 5-1/2" opening with a 12- 1/2" flange, faced true and having a fine-tool finished seat raised 1/32", flange to be drilled with a 10" bolt circle- 8-1" straddling the center lines.

Mud drums will be of steel 149" long, each to be provided with three manholes and two nozzles for blow-off pipe, 2-1/2" opening. The location of the blow-off to be in accordance with drawings approved by the



Company. The mud drum manhole plates to be faced and held in place by handhole bolts and nuts.

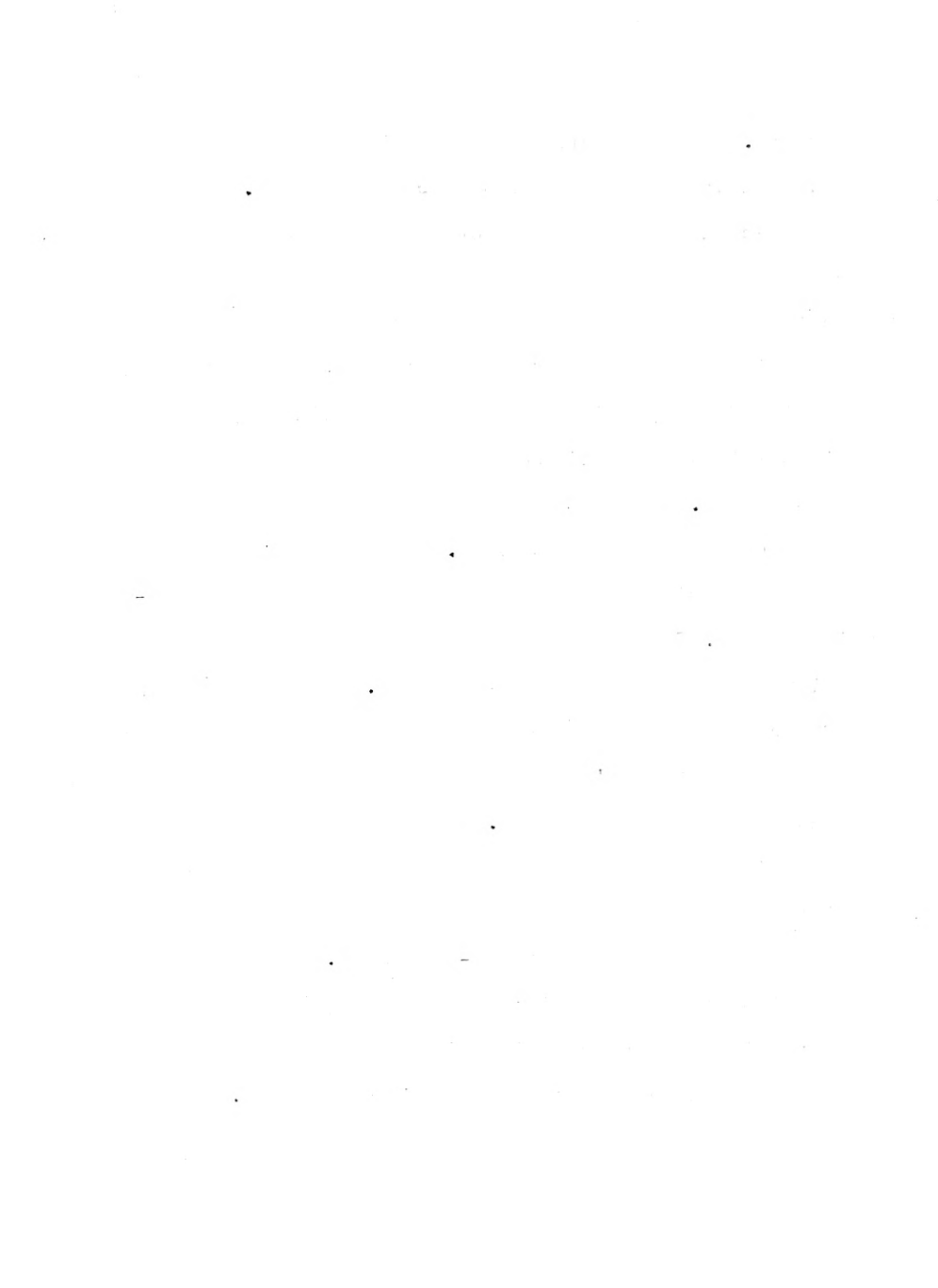
Each boiler to be supported from wrought iron beams of the building and left free to expand or contract entirely independent of, and without affecting the brickwork and so arranged that the removal or repair of any portion of the brick setting may be done without in any way disturbing or moving the boiler connections. The necessary hangers and beam saddles to be provided by the Company.

Each boiler is to be provided with three Consolidated Mfg. Company's nickel seated safety valves 4" diameter set to blow at 210 pounds. To the delivery of each safety valve will be attached a muffler located not less than 4' above and 18" to one side of the center of the safety valve.

With each boiler will be furnished the following fittings:

One steam gauge with 12-1/2" dial.

Two stand pipes with water gauges, each to be fitted independent cleaning pipes and valves and with three patent gauge cocks with lifting handles.



Each drum will be fitted with one combination stop and check valve to be bolted on special bronze padded casting.

All of the above to be connected by annealed brass pipe, all pipe to be extra heavy iron pipe sizes, connecting with composition fittings without gaskets. The pipe to each drum shall be 2" in diameter.

The fronts of the boilers are to be of ornamental pattern, containing large door necessary for access to the ends of the tubes. Tube doors are to be supported from the building structure or from angles to be furnished by the contractor. All parts will be ample in strength with joints fitted. The fixtures of each boiler will consist of, flame bridge plates with bolts and special fire brick lining for the flame bridges , bridge wall girders and bars, binders and bolts.

The regular style of cleaning doors will be furnished for all openings in the walls, necessary anchor bolts for fronts, and wrought iron doors and frames for obtaining access to the rear of the boiler.



With each boiler will be furnished a Babcock & Wilcox superheater guaranteed to superheat the steam 150° Fhr. above the temperature due to the pressure carried. . Each superheater will consist of seamless steel U tubes expanded into forged steel distributing and collecting headers. The ends of the tubes will be readily accessible to handholes, all parts conveniently located for inspection and repair. Proper dusting and clean-out doors will be provided and set to give ready access to the superheated chambers.

All parts are to be tested and made tight under hydrostatic pressure before leaving the shop as follows: Sections, 400 pounds; drums, 325 pounds; mud drums, 325 pounds.

When erected complete on foundation, the whole structure to be tested and made tight at 325 pounds.

In the brick work to be provided by the Contractor, first quality brick only will be used. The fire brick under no circumstances to be wet, but will be dipped in the fire clay batter and laid by rubbing down to place in order to completely fill the joints, making

them as thin as possible. All will be first quality hand burned, without cracks and true surfaces. No bats or bulged bricks will be used in any part of the setting. In laying up the walls, every 5th course will be a header, the walls will be true to line and in every respect a first class job. The bricks are to be laid in mortar composed of one part Portland cement, two parts lime and three parts sand.

At each side of each frame, a fire arch will be provided.

The flange plates will be held in position by a cast iron retaining bars built into the walls. The back corner of the hanging bridge wall to be completely protected by a cast iron girder not less than 10" deep or other approved construction.

3- Design of setting:

Center Walls.

Center wall to be 32" thick with a 6" air space and within the following limits to be laid only with fire brick.

From 12" below the top of the grate at every point 12" above the highest point of the lower row of



tubes, and in the length from the boiler front to 18" back of the front face of the bridge wall. Outside of the above limits, the center walls will be laid with a core of common brick with a face of fire brick at no point less than 4-1/2" thick thru the whole center wall.

Side Walls:

The side walls are to be 17" to 17-1/2" thick and in no place within the furnace dimensions as indicated under, "Center walls", are they to have less than 9" fire brick linings outside the dimensions, the least lining may be 4-1/2".

Rear Wall:

There is to be no brick in the rear wall, except such as may be required above and to the side of the damper frame. The back of the setting below the damper frame is to be made up of wrought iron plates and doors in the usual manner.

Boiler Fronts:

Each boiler front is to be divided into three panels, and each panel is to be provided with two doors, the upper one being the fire door and the low-

er the ash pit doors, The fronts are to be drilled and fitted to receive the Babcock & Wilcox movable chain grate apparatus.

Material:

The panels; splice plates; dead plates; and their chairs are to be of cast iron of a tough gray mixture. The clamps to be of wrought steel. The castings to be free from injurious coal shuts, blow-holes or other imperfections.

Guarantee:

The Contractor guarantees that each boiler, under normal evaporating conditions will generate 17,500 pounds of steam per hour from and at 212 Fhr. at its best evaporative efficiency and will be capable of being forced to give steam capacity 50% in excess of the normal and that when any of the boilers equipped with superheaters is operated under the above conditions, the steam will be superheated not less than 150 Fhr., above the temperature due to the pressure carried,



SPECIFICATIONS FOR FEED WATER HEATER
FOR

FLOODWOOD POWER STATION.

1 - Conditions of Service:

The heater is to supply feed water at 210° F.
for 16- 500 HP. Babcock & Wilcox boilers. The steam for heating the water is supplied from the exhaust of the auxiliaries.

Number of Units:

One Stilwel heater to be furnished.

Capacity:

300,000 pounds of water per hour.

Connections:

Diameter of exhaust opening any size up to 20"

Cold Water Supply 6"

Pump Suction. 11"

Overflow. 6"

Shell:

The shell of the heater is to be of the best grade of cast iron with all joints machined and fitted together with indestructable gaskets to insure



entire freedom from leakage; the water inlet pipe to be of brass. There will be one hinged door large enough to permit of easy entrance to all parts of the heater.

Oil Separator:

Heater to be equipped with an efficient oil separator, which is to practically eliminate the oil from the exhaust steam before it comes in contact with the water. The separator will be self-cleaning and is drained thru a drip pipe which should be connected to the waste ways, and always open.

Overflow:

Overflow is of the sealed type, placed at the back of the heater and arranged with a wide opening at the water line, which acts as a skimmer. The water passes thru this opening to the water seals or traps, which will be of ample size and arranged to withstand a pressure corresponding to that carried in the heater. This arrangement effectively seals the opening and prevents the entrance of air into the heater without a check valve.



Water Supply:

Outside the heater on the water supply inlet there is placed a balanced valve for regulating the cold water supply, which valve is controlled by a ventilated copper float carried in the heater.

Fittings:

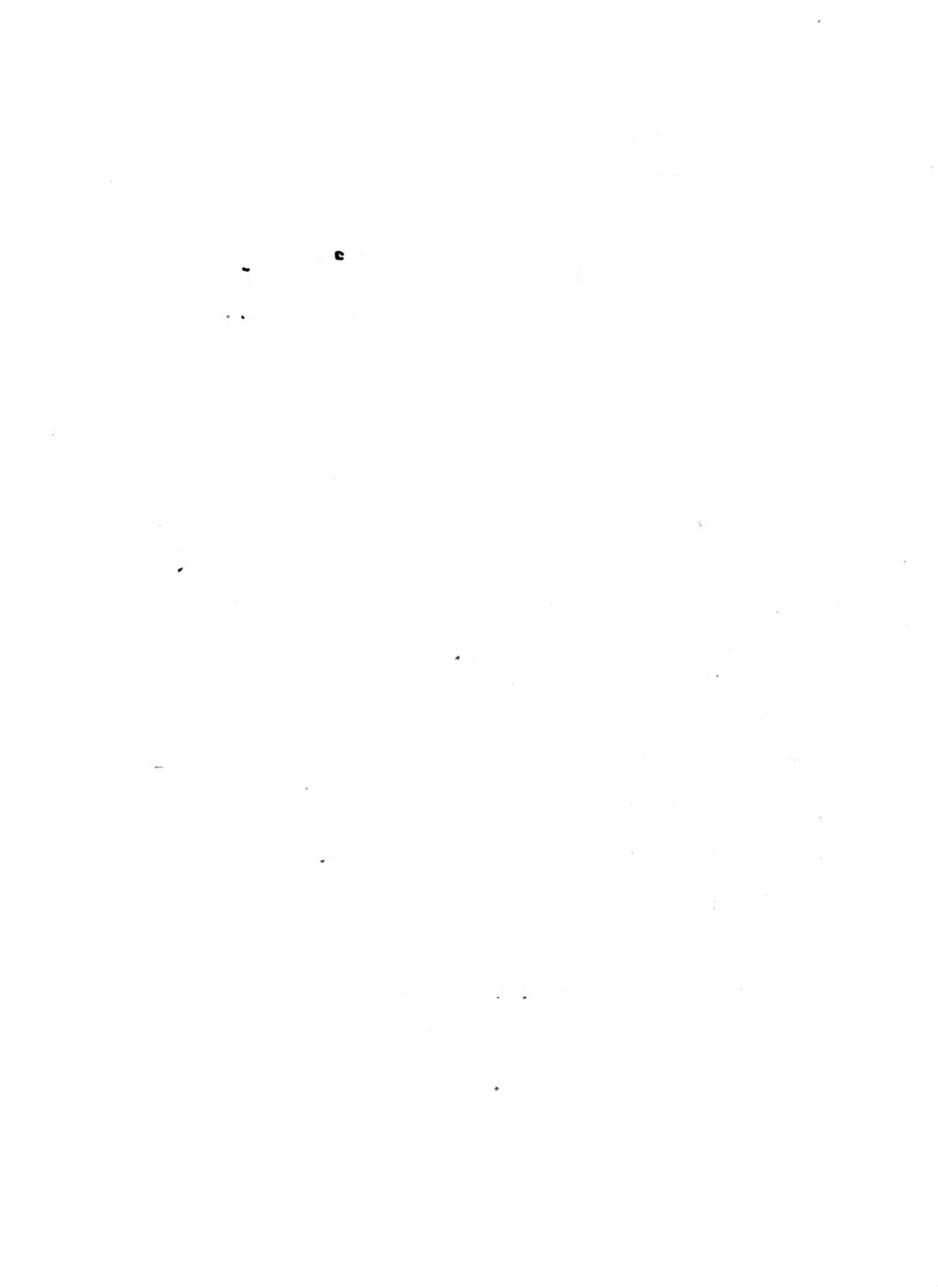
With the heater proper as specified above, there will be furnished the following fittings; ventilated copper float, cold water regulating valve with crank, levers and rods for connecting the same to the float, Babcock, water gauge fitting and all openings for steam and water ready for connection.

Performance:

The heater is sold to perform the following duties, providing it is connected and operated in accordance with instructions of the Contractor.

First:

To deliver water suitable for boiler feed or other purposes; i.e. to give protection against cylinder oil carried in the exhaust steam entering the heater.



Second:

Given a sufficeint and continuous supply of exhaust steam will raise the temperature of the feed water to 210° or 212° FHR.

Third:

The heater will not cause any back pressure on the steam turbine, as the combined areas of the passageways thru it are largely in excess of the area of the exhaust pipe entering it.

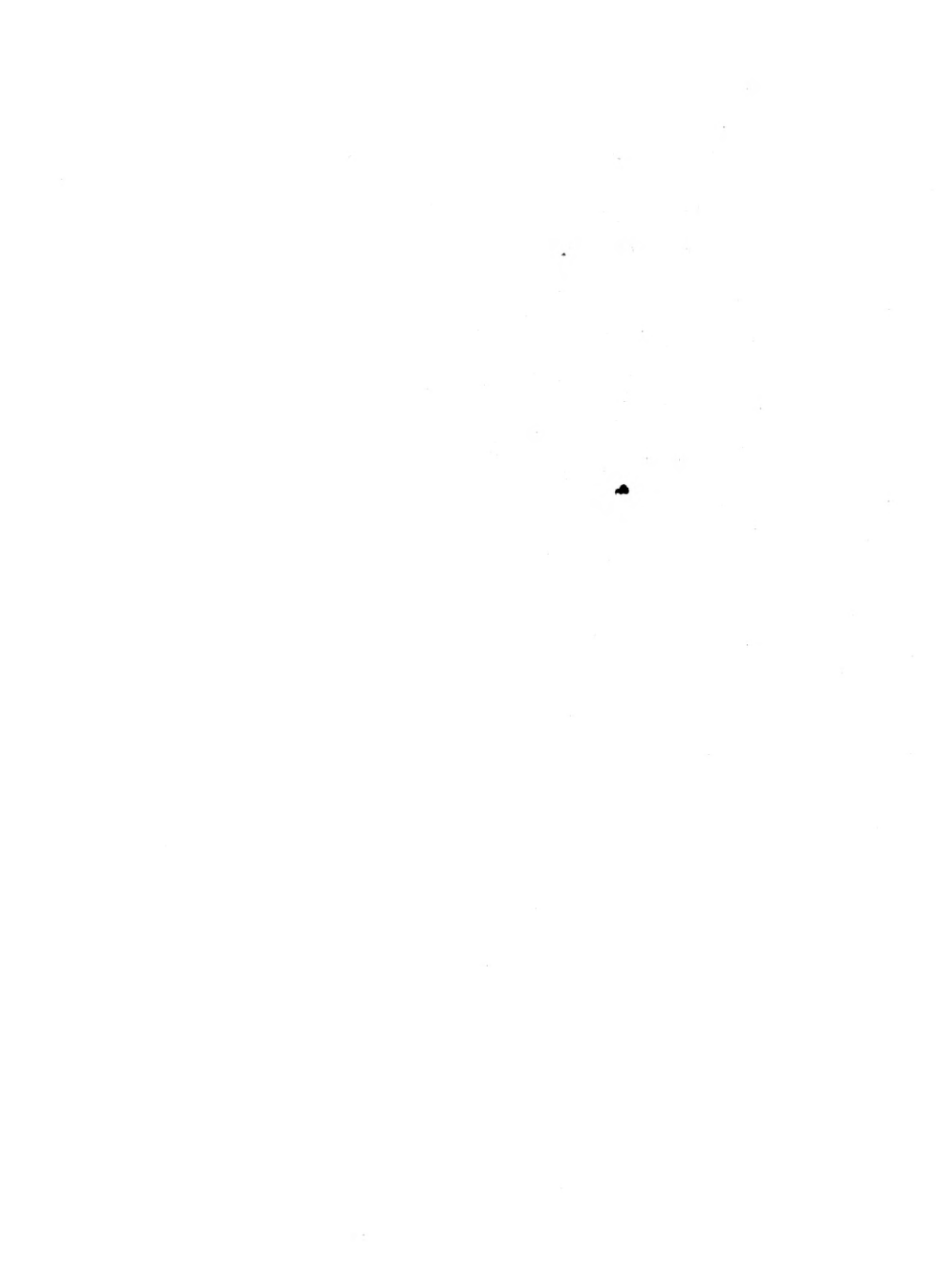
Fourth:

To automatically regulate the cold water supply, keeping it down to the amount actually required over and above the condensed exhaust, thus preventing the waste of water.

Fifth:

The material used and the workmanship furnished to be first class in every respect; the fittings to be of superior quality and particularly adapted to their work. In general the heater is guaranteed to be simple

and highly efficient in operation, easily
and quickly cleaned and thoroughly made in
every particular.



SPECIFICATIONS FOR CONDENSING EQUIPMENTS

FOR

FLOODWOOD POWER STATION.

Conditions of Service:

Each of the four condensing outfits herein-after specified is to be run in connection with a 4,000 KW. Curtis Turbo-Generator, and is to be capable of condensing steam from the same at the rate of 60,000 pounds per hour and maintaining a vacuum of 28" of mercury, referred to a 30" barometer, . when supplied with condensing water at a temperature of 70°Fahrenheit.

Apparatus to be Furnished:

Each equipment will consist of the following items:

- 1 - Condenser.
- 1 - Circulating water pump direct connected to turbine.
- 1 Hot well pump direct connected to a turbine.
- 1 Dry air pump with engine.
- 1 Automatic vacuum regulator.
- 1 vacuum gauge.

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4 - Thermometers.

Description- of one equipment:

Condenser:

The condenser is to be of the Wheeler dry tube type, with a minimum of 10,000 square feet of cooling surface. The body of the condenser is to be rectangular in form and in three parts. It is to be of a high grade of close-grained cast iron and of the proper design and thickness to satisfactorily resist external atmospheric pressure and, in general, for its intended purpose.

It is to be provided with suitable feet so arranged as to permit of its resting upon piers, columns, beams or other supports to be installed for that purpose by this company.

Suitable openings in the proper position on the side of the shell are to be left for the connection of the condenser with the dry air pump. These openings are to be provided with a suitable internal shield to prevent the water of condensation from reaching the pump.

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The bonnets and covers of cast iron shall have suitably placed openings with manhole plates, to allow of interior access without removal of bonnets or covers.

The hot well is to be located at the bottom of the condenser to collect the water of condensation and to it the suction of the hot well is to be connected.

Suitable baffle plates of cast iron are to be provided and so arranged as to effectively distribute the exhaust steam thruout the condensing space and at the same time to drain off the water of condensation. Two supporting plates of cast iron are to be placed in the shell to support the tubes against the impact of the ingoing steam and their own weight.

The tubes are to be uninterrupted, straight, lengths of the best quality seamless drawn brass tubing, #18 B.W.G. $3/4$ " O.D., of a composition of 60 parts copper to 40 parts zinc, without upsets or flanges turned; during the operation of the condenser, all of the outer surface of each tube,



except when enclosed in stuffing boxes and supporting plates, is to be in effective contact with the steam to be condensed.

Suitable stuffing boxes are to be provided for the ends of the tubes, and through which boxes the tubes are to pass, and with sufficient projection to permit of proper packing. The stuffing box is to be of such a design as to ensure easy insertion, removal or packing of tubes, and to allow freedom for expansion and contraction of the tubes.

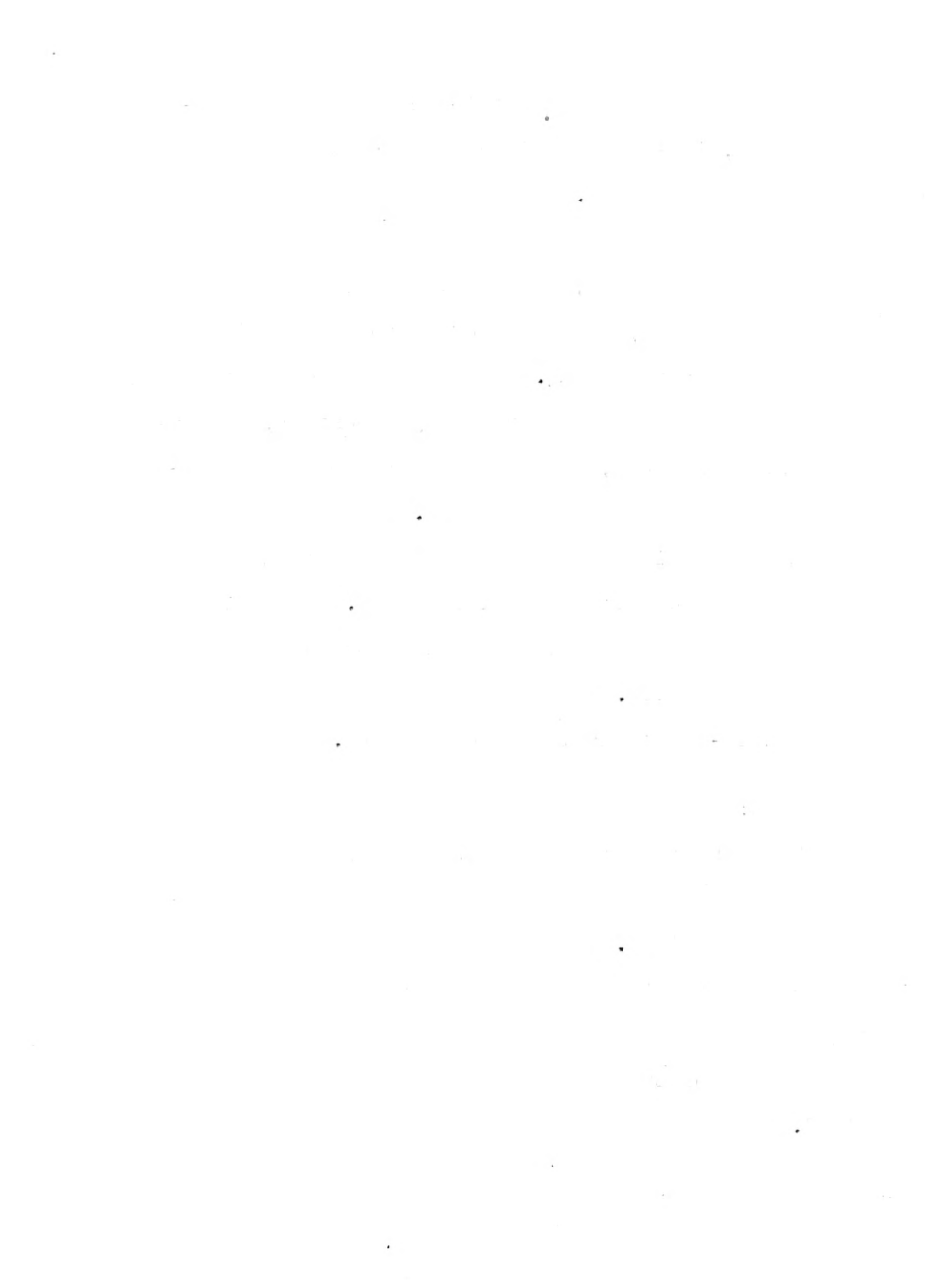
All bolts in contact with water are to be of the best composition with composition nuts. The tubes' heads are to be of the best quality composition and to be 1-5/8" thick.

A blow-off drain is to be provided.

Test:

The condenser tubes are to be subjected to an internal cold hydrostatic pressure test of 500 pounds per square inch.

Acceptance tests of the condensing units shall be conducted by representatives of the Company and the Contractor on such lines as shall later be determined.



Circulating Pump:

The circulating pump is to be of the horizontal shaft volute type having a double suction and enclosed impellers. It is to be a 20" Alberger tri-propeller pump direct connected to a Curtis steam turbine, and to be capable of delivering the necessary quantity of circulating water for the efficient operation of the condenser.

Capacity:

Capacity- 4,500 gallons per minute.

Pump Shell:

Pump Shell to be of Cast iron.

Runners:

Pump runners to be of composition bronze.

Bearings:

Pump bearings to be liberal in size and specially designed and constructed for the work in hand.

Pump Base:

Pump base to be provided with cast iron sub-base specially designed and constructed to take care of the Curtis steam turbine.



Accessories:

All nuts subject to frequent removal will be case hardened and the necessary oil cups and lubricators will be provided.

Turbine:

The circulating pump will be operated by a Curtis steam turbine at 200~~#~~ pressure and 150° Fhr. superheat.

Hot Well Pump.

The hot well pump is to be of the horizontal shaft, two stage volute type having a side suction and enclosed impeller. The pump is to be capable of delivery, against a total discharge head of 30', 200 gallons per minute, from the hot well in which is being maintained a vacuum of 28". The suction and discharge openings are to have diameters of 4" and 4" respectively.

The suction connection is to be of special design and provided with a vapor pipe inlet to the condenser shell and the pump to be of such a design as to permit of the removal of all internal parts without dismanteling it.



The hot well pump is to be operated by a Terry steam turbine at 200# pressure and 150° Fhr. superheat.

Fixtures:

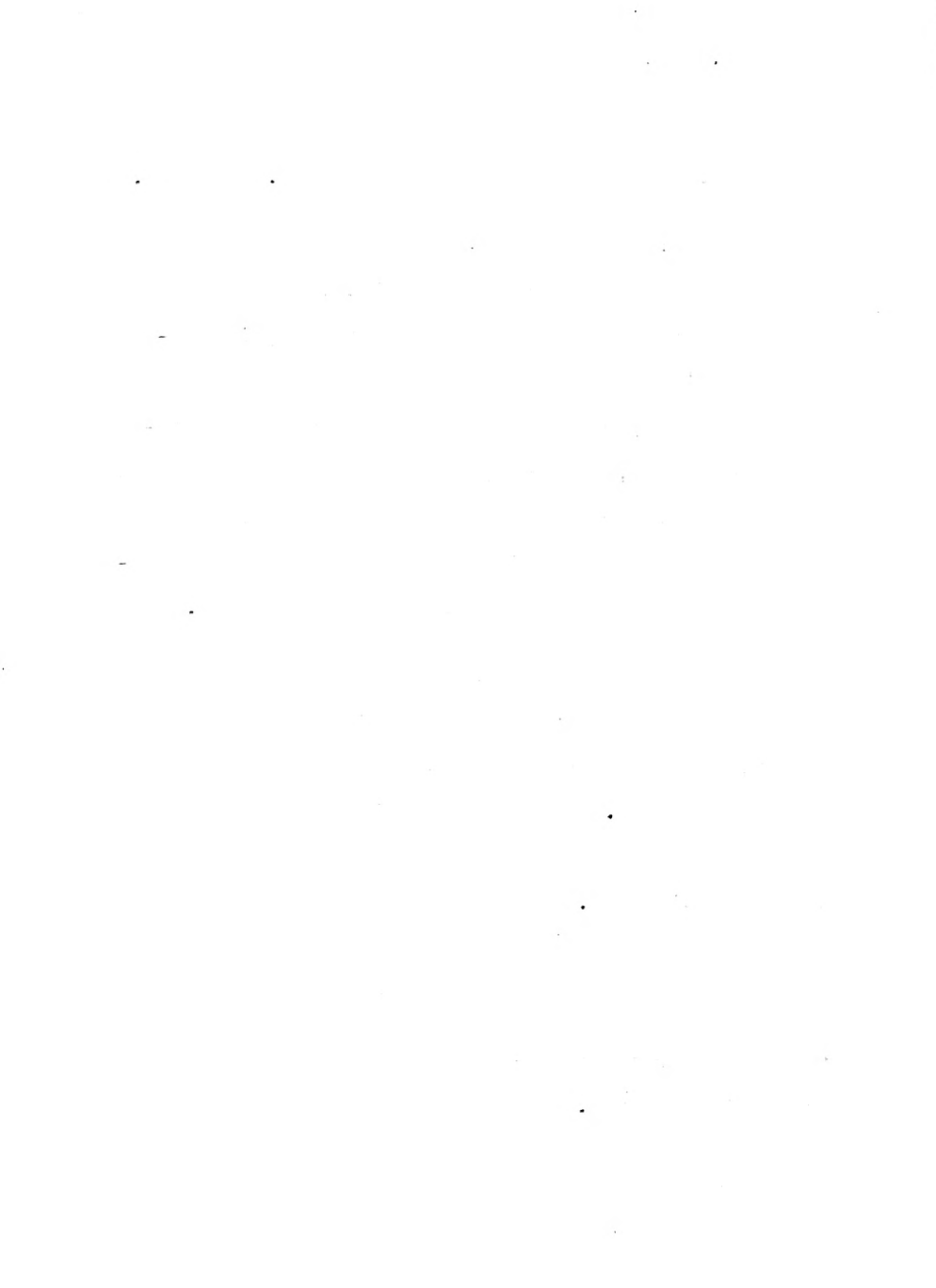
All the usual and necessary fixtures thruout shall be furnished for each condenser unit, including a Water's throttling governor for steam end of the vacuum pump, positive feed, sight feed lubricators, hand valves, oil cups, grease cups, cylinder relief cocks and drain cocks, the vacuum and pressure gauges and thermometers and their wells as hereinbefore specified and a complete set of drop forged wrenches.

Dry Vacuum Pump:

The dry vacuum pump is to be of the horizontal pattern, having steam and vacuum cylinders mounted on a common bedplate. The cylinders in addition to being mounted upon bedplates are to be rigidly connected by horizontal tie rods.

Size:

Each dry vacuum pump is to have one 8" X 18" steam cylinder and two 18" X 18" vacuum cylinders working in multiple.



Speed:

The normal speed of these vacuum pumps to be 100 RPM., but are to be capable of operating at a lower rate of speed according to the requirements of the service. Steam pressure for most economical operation 200 pounds.

Steam Cylinders:

Steam cylinders are to be of close-grained iron of ample thickness for re-boring. To be provided with indicator openings.

Steam and Exhaust Valves.

These valves are to be of the Corliss type, cylindrical in form and operated by a standard releasing gear, and permitting of high speed in case of emergency without undue noise or jar.

Regulating Governors:

The regulating governors are to have levers with sliding weight adjustments and constant speed motion. Any variation of speed necessary is to be accomplished by an adjustment of the governor while running, the



function of the governor being to maintain a speed that is constant under all conditions of load, due to fluctuations of vacuum and steam pressures.

Water Jackets:

The vacuum cylinders and also the front and back cylinders heads are to be water jacketed for the circulation of cooling water.

Air Valves:

The outlet air valves are to be of special composition and automatic in their action, these valves are to be guided by tubular stems sliding in tubular guides and held to their seats by light composition springs. The inlet valve is to be of the slide valve type operated by means of an eccentric and suitable valve rod connections from the main crank shaft.

These positive inlet valves are to be provided with a flash port which is to connect the two ends of the air cylinder when the air piston is at the extreme end of the stroke and in this manner to allow the air atmospheric pressure in the clearance space back into



the opposite end of the cylinder at the end of the stroke, reducing the pressure in the clearance space to practically to that of the vacuum being carried and thus eliminating the prejudicial effect of the clearance. Particular care to be had that the valve faces and seats of the slide valves are free from patches and any imperfections, and that they are scraped to a true flat surface all over.

Fly Wheels:

There are to be for each machine two fly wheels approximately 4' in diameter and of ample weight.

Lagging:

The steam cylinders are to be covered with best nonconducting material and encased with No. 14 B.W.G. sheet steel lagging.

Foundation Plans:

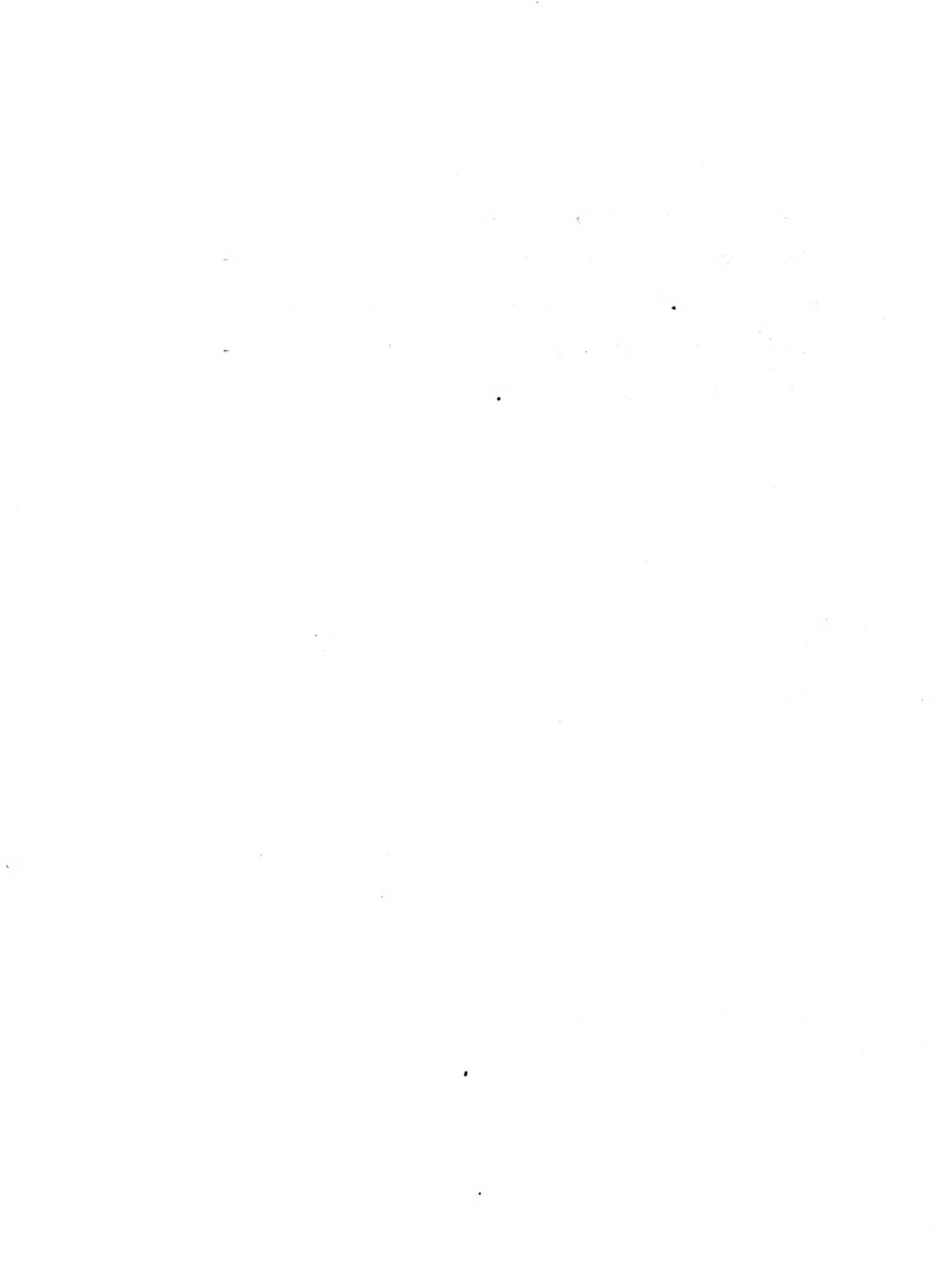
Complete foundation plans showing the position of the foundation bolts size of steam and air openings are to be furnished.

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Workmanship and Material:

All workmanship, material and finish are to be first class and in keeping with the best engine practice. The vacuum in the air cylinder to come within one pound of absolute when nozzle of inlet is blanked off.



Painting:

Before leaving the shop and after inspection by the Engineer, the exteriors of the condenser bodies and of the castings of the pumps are to receive a coat of filler and a finishing coat of paint, and the interior two coats of an anti-rust metallic paint and the engines and turbines of the circulating, hot well, and the dry vacuum pumps are to receive a filler, be rubbed smooth and finally painted.

The paintings shall not in either or any case be done until after the castings have been inspected by the Company's representative.

Guarantees:

The Contractor guarantees that each condensing unit will continuously condense 60,000 pounds of steam per hour and uninterruptedly maintain a vacuum of 27- 1/2" as read by a mercury column; each guarantee being referred to an intake temperature of the circulating water of 70° Fhr., and a barometer reading 30 inches. These guarantees are also conditional on the apparatus not furnished by the Contractor being sub-

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stantially tight and free from air leaks. Should these guarantees fail to perform with a cooling surface of 10,000 square feet, the Contractor is to install additional cooling surface until the terms of his guarantee are met, up to and including a total cooling surface of 15,000 sq. ft, for each condensing unit. A failure to meet these guarantees with 15,000 square feet of cooling surface will be sufficient cause for rejection of the apparatus.

The Contractor further agrees that all the auxilliary apparatus for each unit will be of ample capacity for its purpose as initially installed by him, and that the equipments thruout will be efficient and satisfactory appliances for their intended purposes under the conditions hereinbefore stated; and he further guarantees for the term of one year all material and workmanship entering into the construction, and within that time will replace, without charge therefor, any imperfect part.



SPECIFICATIONS FOR THE
TURBINE DRIVEN CENTRIFUGAL BOILER FEED PUMPS
FOR
FLOODWOOD POWER STATION.

General:

Each of the units will consist of a 6" five stage pump direct-coupled by means of flexible coupling, to a steam turbine being mounted on a heavy cast iron baseplate, making the unit self contained. Each pump will have a rated capacity of 650 gallons per minute when operating against a total head of 700 ft., approximately 300 pounds at a normal speed of 1650 RPM. There will also be one 6" check valve for each pump for 300 pounds working pressure.

An approved throttle will be furnished with each turbine and the necessary special wrenches will be supplied for both turbines and pumps.

Workmanship Guarantee:

The pumps, turbines and appurtenances are

guaranteed against defective workmanship and the material for a period of one year from the date of shipment, and should any defect develop within this time a new part will be furnished to replace the same, without charge.

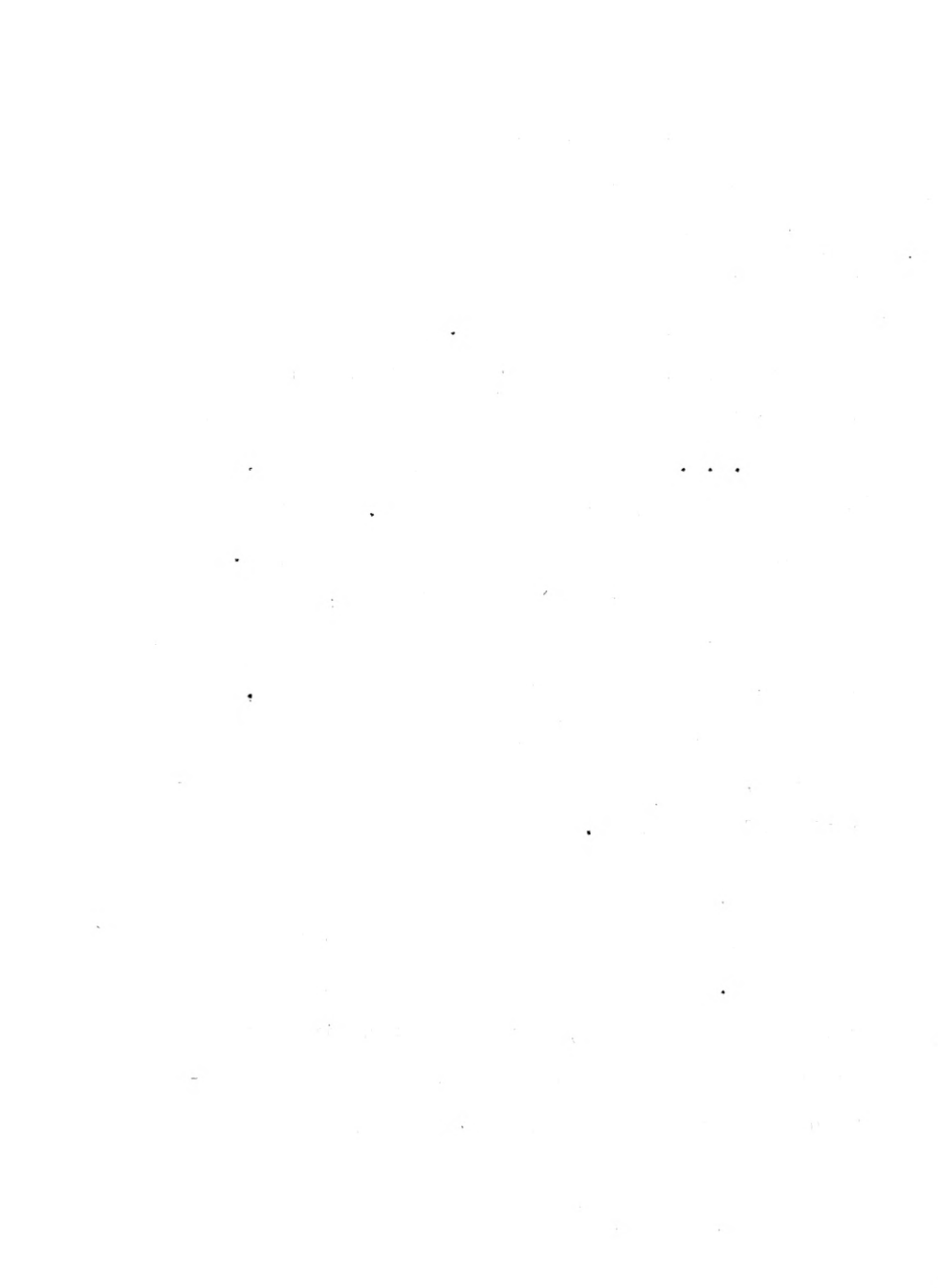
We guarantee the efficiency of the pump end of the unit to be not less than 65% when delivering 650 g.p.m. against a total head of 700 ft., when handling water not exceeding 200° Fhr. delivered to the suction under a head of not less than 6 ft.

Measurements to be made as follows:

The total head shall be measured by a gauge placed close to the suction inlet of the pump, and a gauge placed close to the discharge outlet of the pump, with the necessary correction for the location of the gauges.

Pumps:

The pumps will be of the single suction five stage type. The pump case will be horizontally divided thru the center, thus permitting inspection and cleaning the interior, without disturbing suction or discharge piping, or bearings, or disturbing



of the steam turbine or alignment of turbine or pump.

Capacity:

Capacity- 650 U.S. gallons fresh water per minute against a total suction and discharge head of 675 ft. While the pumps are designed for 285# pressure, this may be made much less if desired, by reducing the speed of the turbine and pump, and there will be no difficulty in bringing the speed down to a point to maintain 175# discharge pressure, or to any point between 175# and 285# that might be desired. The maximum quantity of water delivered at any pressure will be maintained at approximately 650 gallons.

Governing Devices:

To maintain a constant discharge pressure with varying quantities of water(automatically), a pressure regulator will be supplied to operate in conjunction with and be a part of the turbine governor for a constant speed; or if it is found more advantageous, a separate regulator will be supplied to control the pump



independently of the turbine constant speed governor.

It is, therefore, contemplated that the pump will be entirely automatic in its operation when maintaining a constant discharge pressure.

Balancing Device:

The pump will be balanced against end thrust in such a manner that the stuffing box at the discharge end of the pump will be subjected to pressure slightly above atmospheric. This pressure will be controlled and maintained by means of a relief valve, the drain from the relief valve being carried to the pump suction, thus preventing the waste of water.

Impellers:

Impellers to be of the single suction type, properly proportioned for the duty, and made of bronze.

Guide Vanes:

Guide vanes will be cast solid with the supporting ring with a separate cover ring or side plate, all of



bronze, and removable from pump case.

Packing;

Stuffing boxes with glands take-up studs are to be provided for fibrous packing.

Bearings;

Bearings are to be of the self oiling type, ball seated, split and removable, and so arranged that no oil can pass into the pump case. In connection with the bearing housings, are cast drip pockets for collecting the drips from the stuffing boxes.

Mounting:

Both pump and turbine will be mounted on a one-piece sub-base of cast iron, turbine and pump to be connected by flexible coupling.

Steam Turbine.

The turbine will be of the single wheel Terry type, and such a design that the main portion of the turbine case is subjected to exhaust pressure only.

Steam Conditions:

The turbine is to be designed for 200# steam press-



ure at the throttle, and 150° F. superheat. They will be designed to operate at 225 # pressure, when necessary, and will be capable of delivering full rated power with 180 pounds gauge pressure saturated steam.

The rated capacity of each turbine will be 200 brake HP. when operating at a speed of 1650 RPM. In order to secure a less quantity of water than the rated capacity of the pump, the turbine will be so designed that it may be operated at a speed as low as 1450 RPM.; or any speed between 1450 and full speed. At the reduced speeds, the turbine shall have sufficient capacity to drive the pump when delivering the lesser quantity of water.

Governing Devices:

A fly-ball type centrifugal governor to be mounted on the main turbine shaft, and will operate in connection with the balanced type of piston valve for maintaining the turbine at a substantially constant speed. This design of governor is subject to any changes that may be found necessary, under subject "Governing Devices", for pumps.



Shaft:

Turbine wheel will be mounted on a shaft of hammered steel, and will measure 2- 3/4" in the bearings.

Bearings:

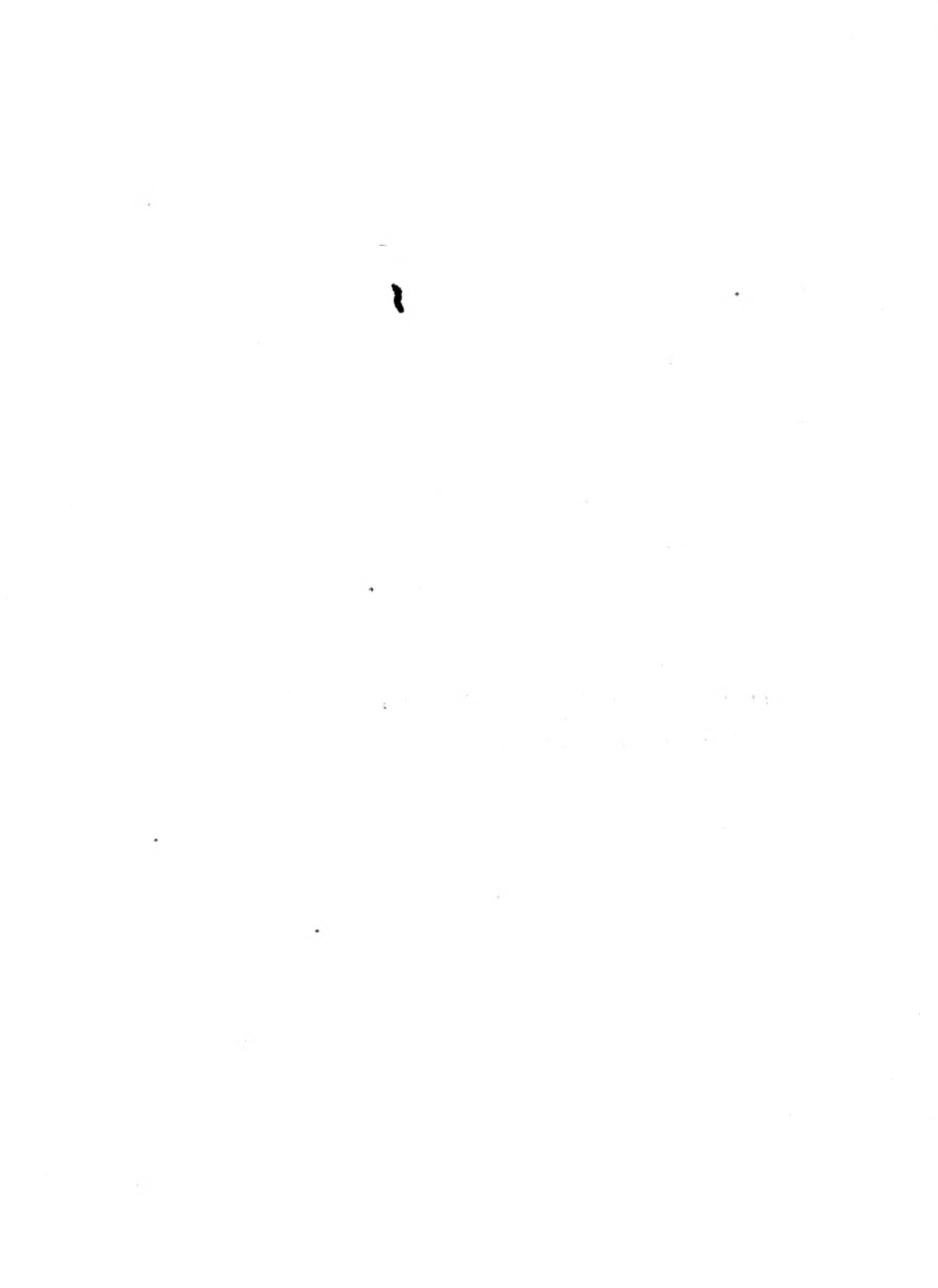
Bearings are to be of the self-oiling type, with oil rings for each bearing; bearings to be split and removable, of cast iron lined with best babbit metal, supported at the center only and enclosed by dust-proof felt washers.

Case:

The case will be of cast iron, made in two pieces, divided horizontally thru the center, and permitting of the inspection of the turbine wheel, without disturbing the steam or exhaust connections. The housings for supporting the main bearings will be cast with the lower half of the case.

Mounting:

Turbine will be mounted on the same sub-base supplied with the pump, and connected to the pump



by means of a flexible coupling.

Steam Consumption:

With 200# steam pressure and 150° Fhr. super-heat at the throttle, and no back pressure, the Contractor guarantees the turbine to use not to exceed 32# of steam per brake H.P.



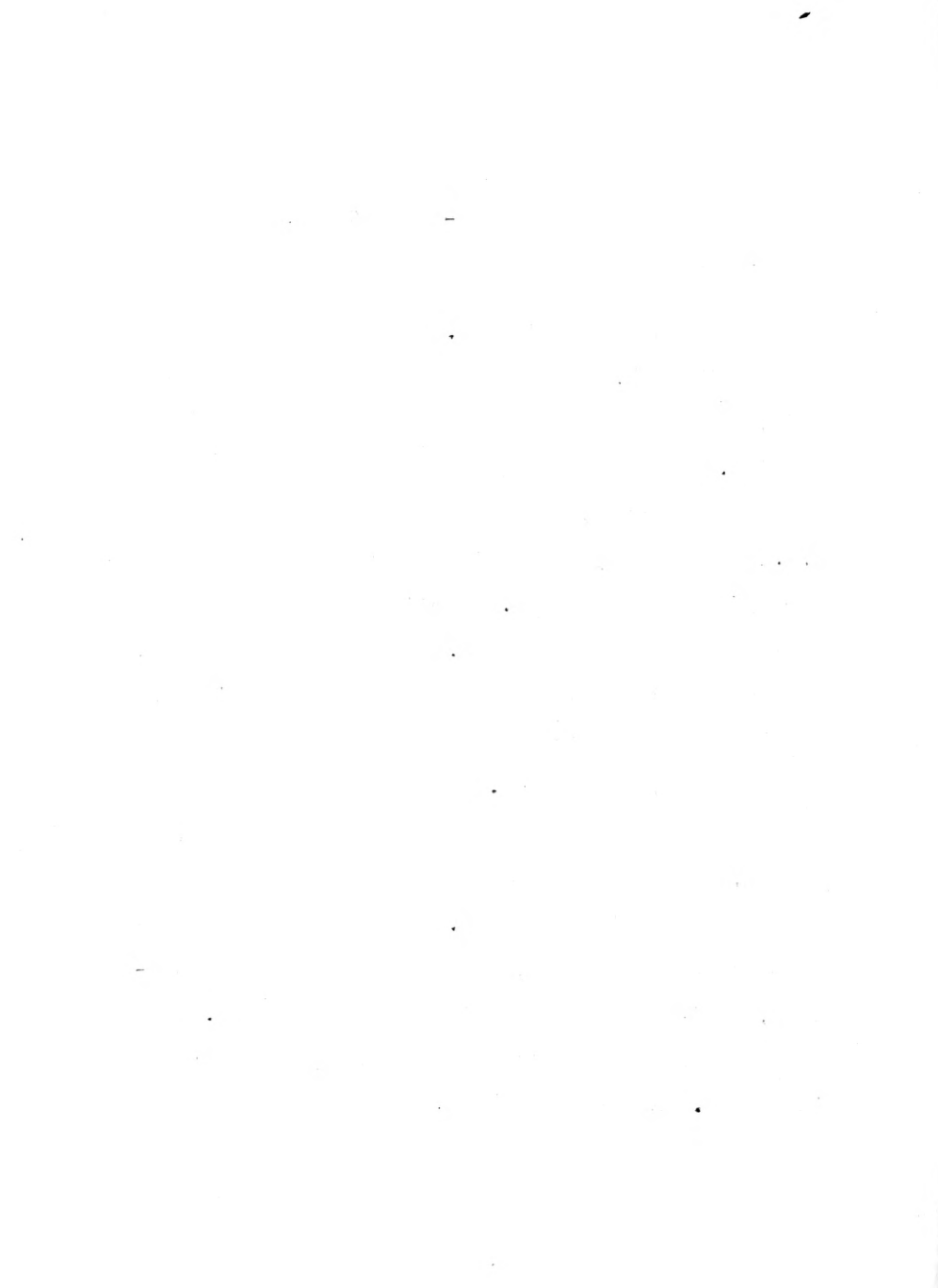
A DESIGN FOR THE HOCKING VALLEY POWER PROJECT.

IV DESIGN OF SUB*STATION

13- General Description.

The substation is to be located at Columbus Ohio, a distance of 59 miles from the central power station. It will be a combined railway and transformer substation, having a rated capacity of 5,000 K.W., of which 3,000 KW will be supplied to the railway system and 2,000 KW. supplied to the city for lighting and power purposes. This substation is to be operated in parallel with stations of a similar character located conveniently, to supply the cities of Lancaster, Logan, etc.

The building is to be of neat appearance, simple, and of such an architectural design as is best suited to its location. It will be constructed of concrete thruout, supported on concrete footings, making an entirely fire-proof structure. The building will be rectangular in shape, 80'X 70'and 55' in height. A concrete wall running the length of



the building divides it into two sections; one to contain all the high tension apparatus, and the other, an operating room containing all the machinery and main switchboard.

Particular care has been taken with the high tension apparatus to simplify the installation and to provide the necessary protection and clearance between the high tension lines. The transmission lines are brought in at the rear of the building, thru 4' openings, being protected on the outside by weather proof hoods. On the inside, each wire of the 3-3 phase lines in turn passes thru disconnecting switch, choke coil, lightning arrester, H_2 oil switch transformer disconnect and rotary transformer to the 1,000 KW. converter.

Thus each 3 phase line goes directly to one converter. On each of these lines taps are taken off between the oil switch and the transformer disconnects, and connect to a 70,000 volt bus thru another set of disconnects. This bus is well protected and runs along the wall of the high tension compartment, and to it are connected the lightning and power transformers.

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This arrangement allows any one of the lines to be used to supply the commercial load or to connect all the lines in parallel.

The arrangement of the apparatus in the operating room is shown in the plan and elevation drawings of the substation. The transformers and starting panels are directly behind each converter unit and the main switchboard at one end of the room.

14.- Electrical Equipment:

(a) Converters.

There will be 3-1,000 KW. rotary converters of the railway type. Each machine is a six phase unit, and will supply 1,665 amps. at 600 volts(D.C) to the trolley under full load conditions. Under normal operating conditions, the converters will be started from the A.C. side, but provision has been made for starting from the D.C. side and the necessary synchronizing connections provided. The normal AC. voltage is 213, but this will be reduced to $1/2$ of this value for starting by the proper transformer taps. The supply current is 25 cycle and with an 8 pole machine the normal speed will be 375 RPM.



(b). Transformers:

All the transformers are of the three phase type with a primary voltage of 70,000. The rotary transformers are 1,000 KW. each, having a full load primary current of 8.4 amps., and a secondary current of 785 amps. An auxiliary A.C. low tension bus has been provided and arranged so that any one of the transformer sets may be connected to any one or all of the converters, or all the secondaries connected in parallel. The connections for the above are shown in the substation wiring diagram.

The lighting and power transformer is of the three phase type, 2,000 K.W. capacity and 2200 secondary voltage. As previously stated, may be connected to any one of the three incoming lines.

(c) Oil Switches.

There are three high tension G.E. type H motor operated oil switches, one on each of the incoming lines. These are three phase switches and each leg is placed in a separate isolated compartment. These are equipped with overload relays



and may be operated from switchboard. The operating and control buses are supplied from storage cells placed in the basement.

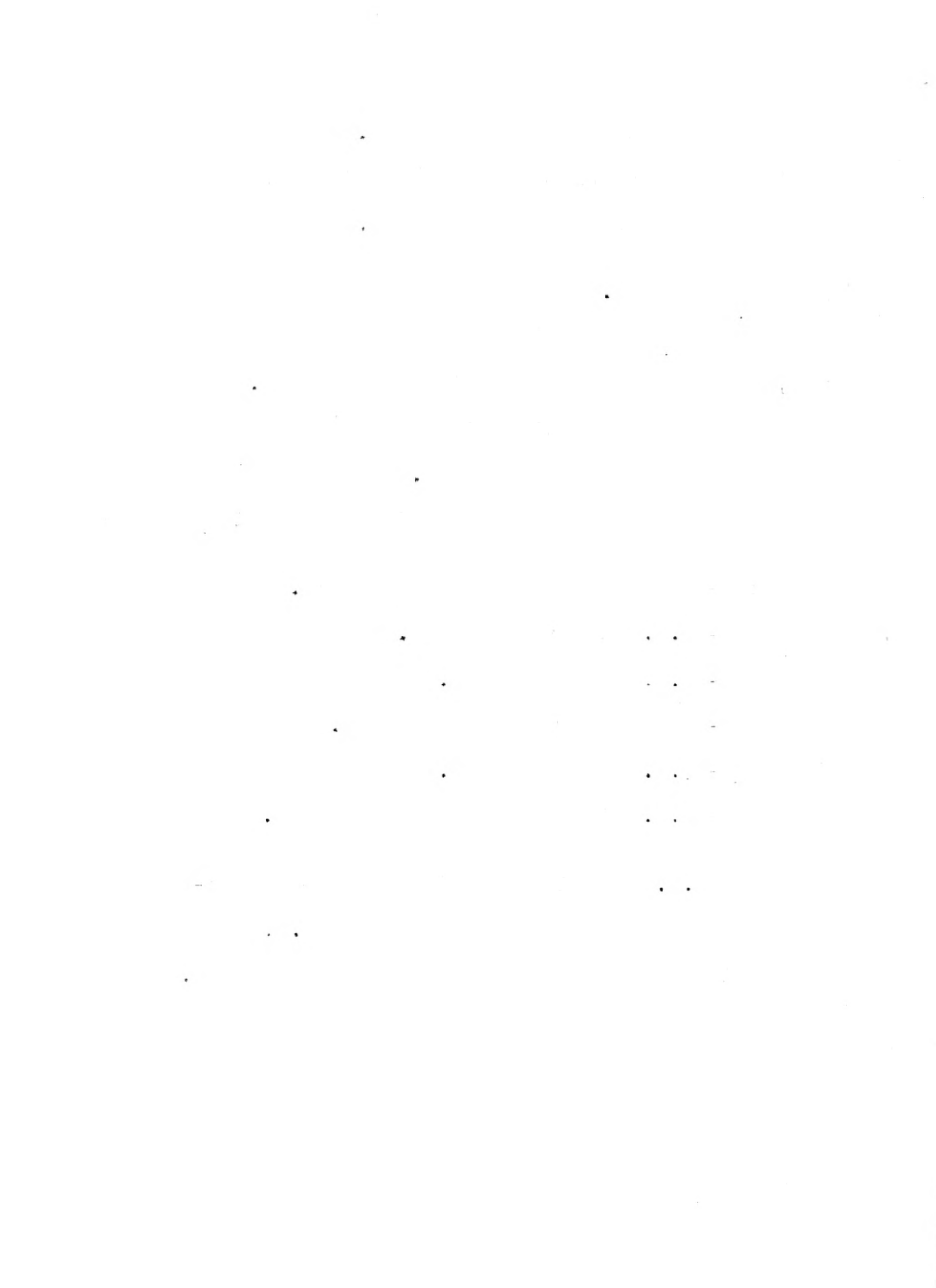
(d) Switchboard.

The switchboard is to be of black Monson slate, supported on an angle iron frame work. The front elevation given with wiring diagram shows the general arrangement of the board.

The switchboard consists of the following panels;

- 3 - 3 phase incoming line panels.
- 3 - D.C. Converter Panels.
- 4 - D.C. Feeder Panels.
- 1 - Storage Battery Panel.
- 2 - A.C. Feeder Panels.
- 1 - A.C. lighting transformer panel.

The A.C. starting and field break-up switches are located at the machine and the D.C. unit and equalizer switches are mounted on the machine.



A DESIGN FOR THE HOCKING VALLEY POWER PROJECT.

V DESIGN OF TRANSMISSION LINE.

15. Choice of System.

The system to be used in transmitting energy to the Columbus substation will be the three phase alternating current of 25 cycles per second and at a voltage of 70,000.

Three lines are to be constructed to operate in parallel. Each line is designed to carry one-half the total load. The size of the conductors is determined by applying Kelvin's Law, as explained in, " Overhead Electric Power Transmission" by Still.

The conductors are to be carried on flexible steel towers, one tower supporting the three lines. Each three phase line is to be carried on the vertices of a triangle. Arrangements are to be made at the central station and at the substation for grounding the upper line during electrical storms. The wires are transposed every ten miles so as to eliminate mutual inductance.



16 Calculations.

$$\text{Power} = \frac{5000}{2} = 2,500 \text{ KW.} = 3,360 \text{ HP.}$$

$$E = 70,000$$

$$\text{P.F.} = 0.85$$

$$\text{Distance } 60 \text{ miles.}$$

$$\text{Copper Cost} = \$15 \text{ per } 100\#$$

$$\text{Percentage to cover depreciation and annual interest on copper.} = 12.5\%$$

$$\text{Cost of wasted power per HP. per year} = \$12.$$

$$\text{Economic voltage drop per mile}$$

$$= e = \frac{8.1 \sqrt{12.5 \times 15}}{12} = 32 \text{ volts.}$$

$$\text{Transmission voltage} = 70,000$$

$$\text{Current per conductor} =$$

$$I = \frac{2500000}{\sqrt{3 \times 70,000 \times 0.85}} = 24.4 \text{ amps.}$$

$$\text{Resistance per mile of conductor.}$$

$$= \frac{32}{24.4} = 1.31 \text{ ohms.}$$

$$\text{Resistance per } 1000 \text{ feet,} = 0.24 \text{ ohms.}$$

$$\text{The wire best suited for this installation is}$$

$$\# 2 \text{ B \& S Gauge, weighing } 200\# \text{ per } 1000 \text{ ft.}$$



Power lost in line.

$$= 3 \times \text{length of line} \times T \times E.$$

$$= 3 \times 60 \times 32 \times 24.4 = 14,100 \text{ watts.}$$

$$\% \text{ power loss} = \frac{14.1 \times 100}{2500} = 5.64 \%$$

Voltage drop of line due to resistance.

$$= 3 \times 32 \times 60 = 3,280.$$

Line to line voltage at receiving station is 3,280 volts less than voltage at generator, due to resistance drop.

Spacing of Lines and Conductors.

The distance from the central point of each line to either of the other lines is to be 8'

Distance between conductors in the same line is 75"

Calculation of Inductance.

From formula given by Prof. Freeman.

Total inductance per mile - (M + L)

$$= (0.742 \log \frac{D}{r} + 0.085) \times 10^{-3}$$

$$D = 75'' ; r = 0.1288''$$

$$L = 124 \text{ milli-henrys (total)}$$

Capacity.

$$L = \frac{0.0388}{\log \frac{D}{r}} = \frac{0.0388}{2.72} = 0.01425 \text{ m.f. per mile.}$$



$$L = 60 \times 0.01425 = 0.853 \text{ m.f.}$$

$$\text{Resistance per wire} = 50.5 \text{ ohms.}$$

$$\text{Inductive reactance} = 2\pi f L = 19.5 \text{ ohms.}$$

$$\text{Capacity reactance} = \frac{1}{2\pi f C} = 7,480 \text{ ohms.}$$

Regulation.

Charging Current.

$$I = \frac{70,000}{\sqrt{3} \times 7480} = 5.4 \text{ amps.}$$

$$\text{Line Current} = 20.7 \text{ amps.}$$

Generator Voltage.

$$\sqrt{3 \left(40,500 + 20.7 \times 50.5 - \frac{5.4}{2} \times 19.5 + j 20.7 \times 19.5 + \frac{5.4}{2} \times 50.5 \right)} = 72,000.$$

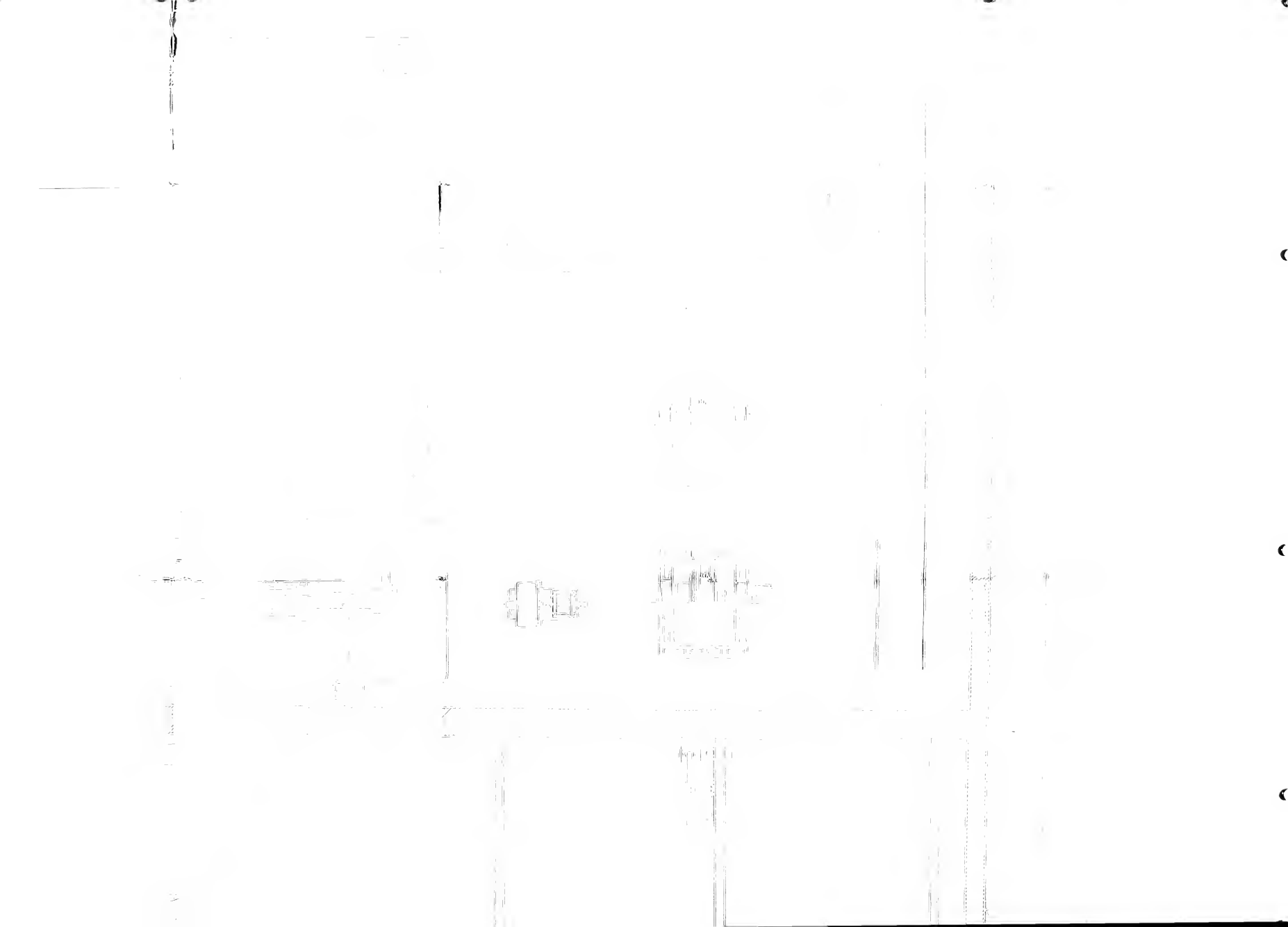
No load receiver voltage with 72,000 generator volt.

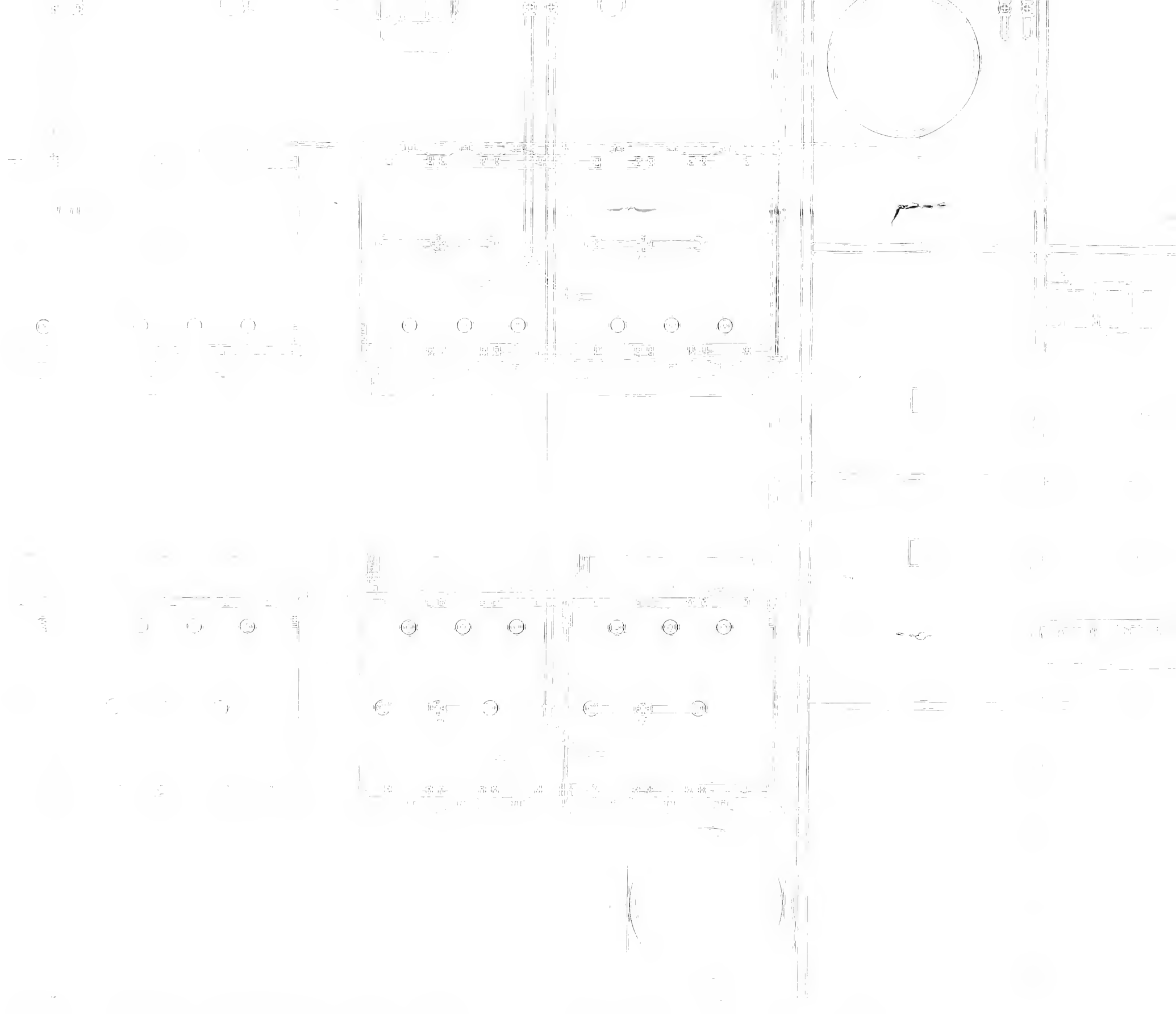
$$= 72,050.$$

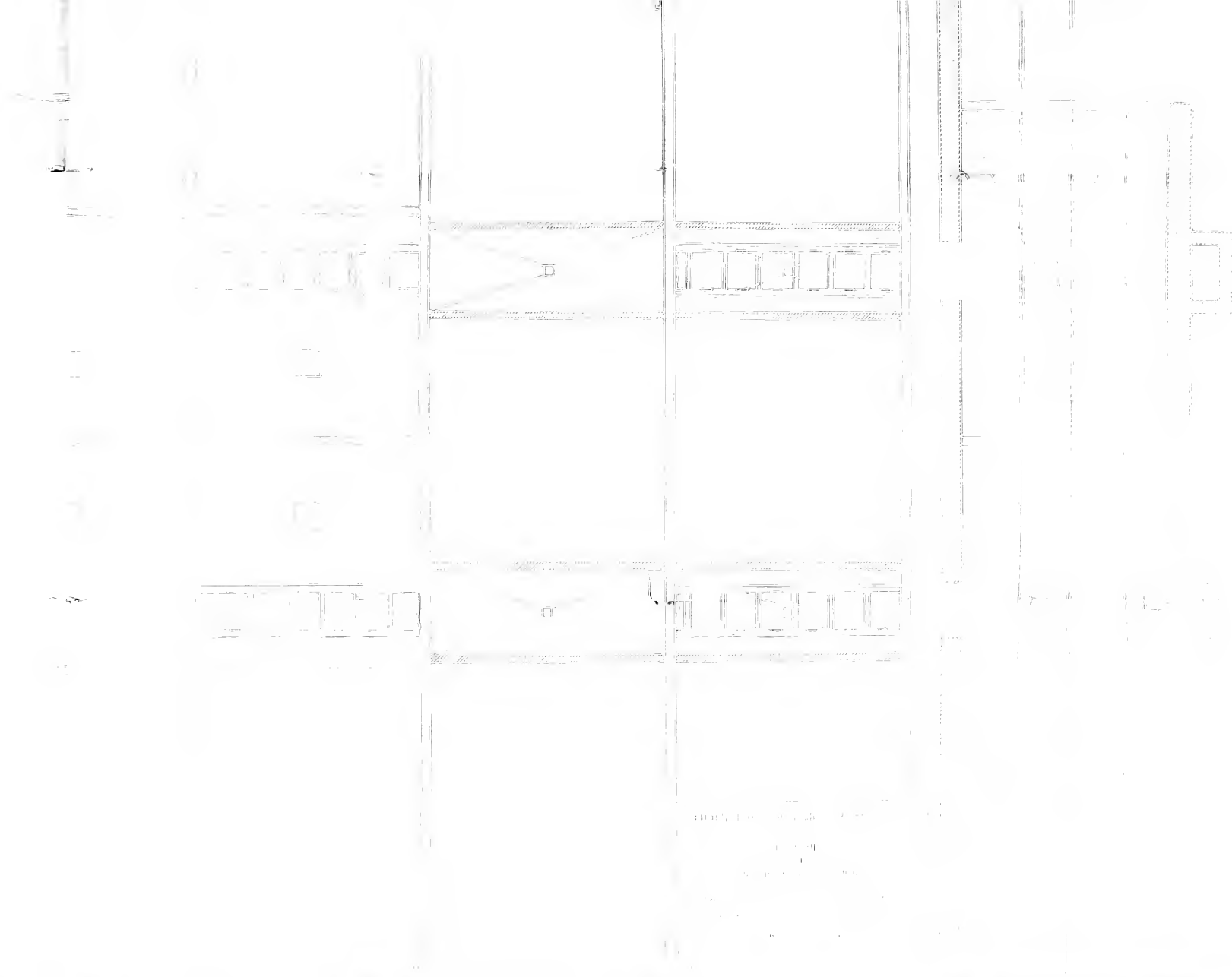
$$\text{Regulation} \frac{72,050 - 70,000}{70,000} = 3.1\%$$

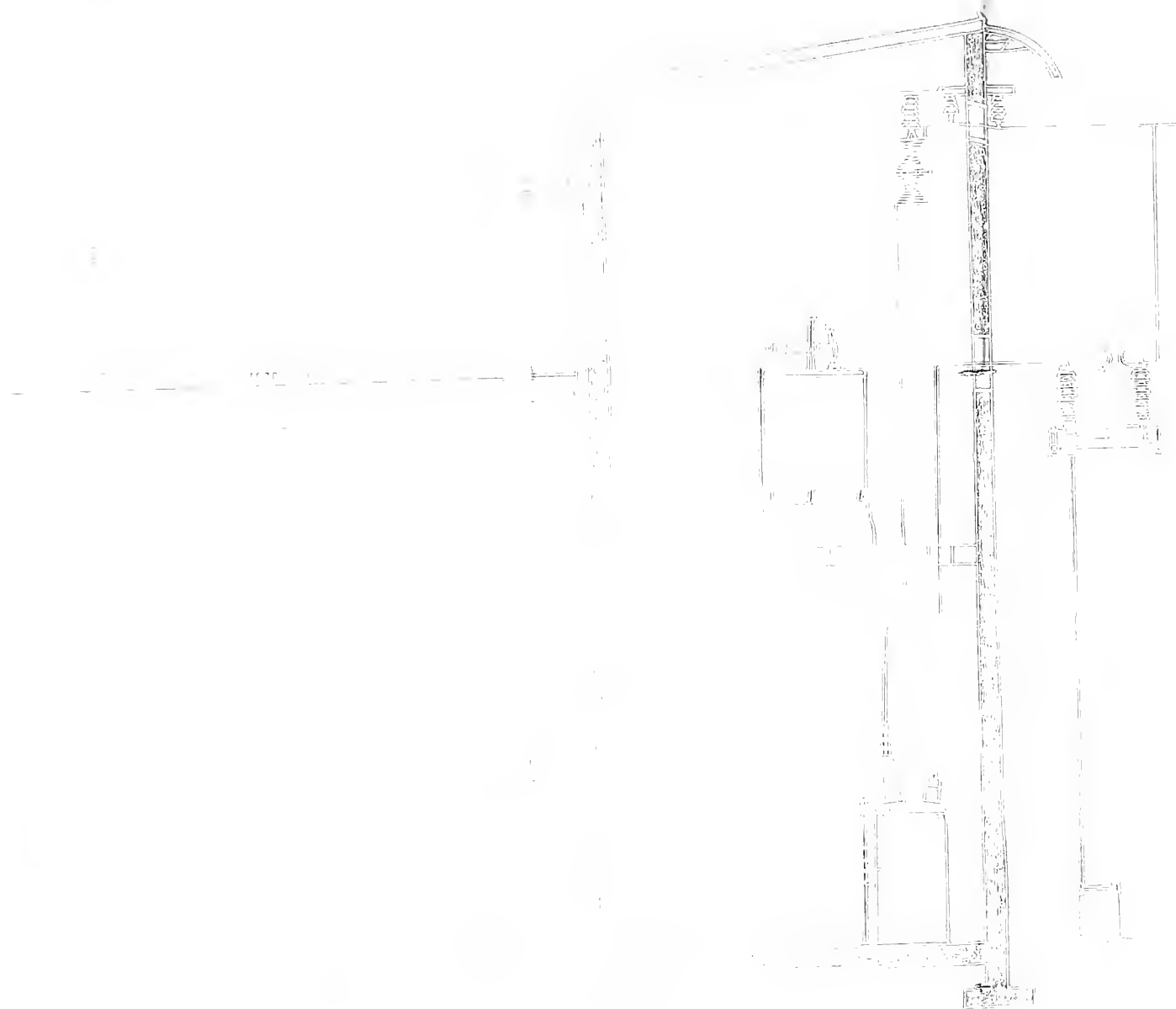


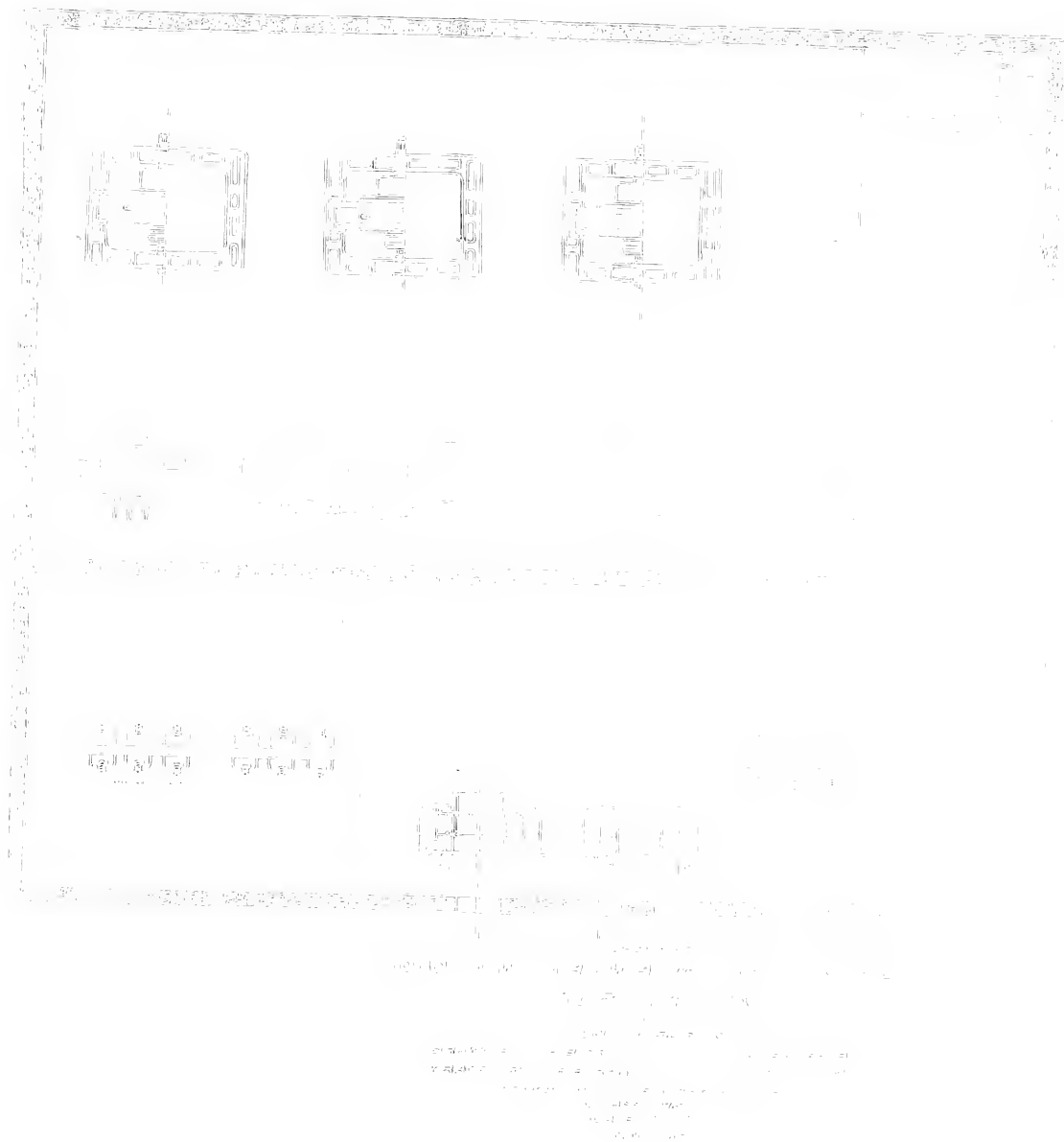












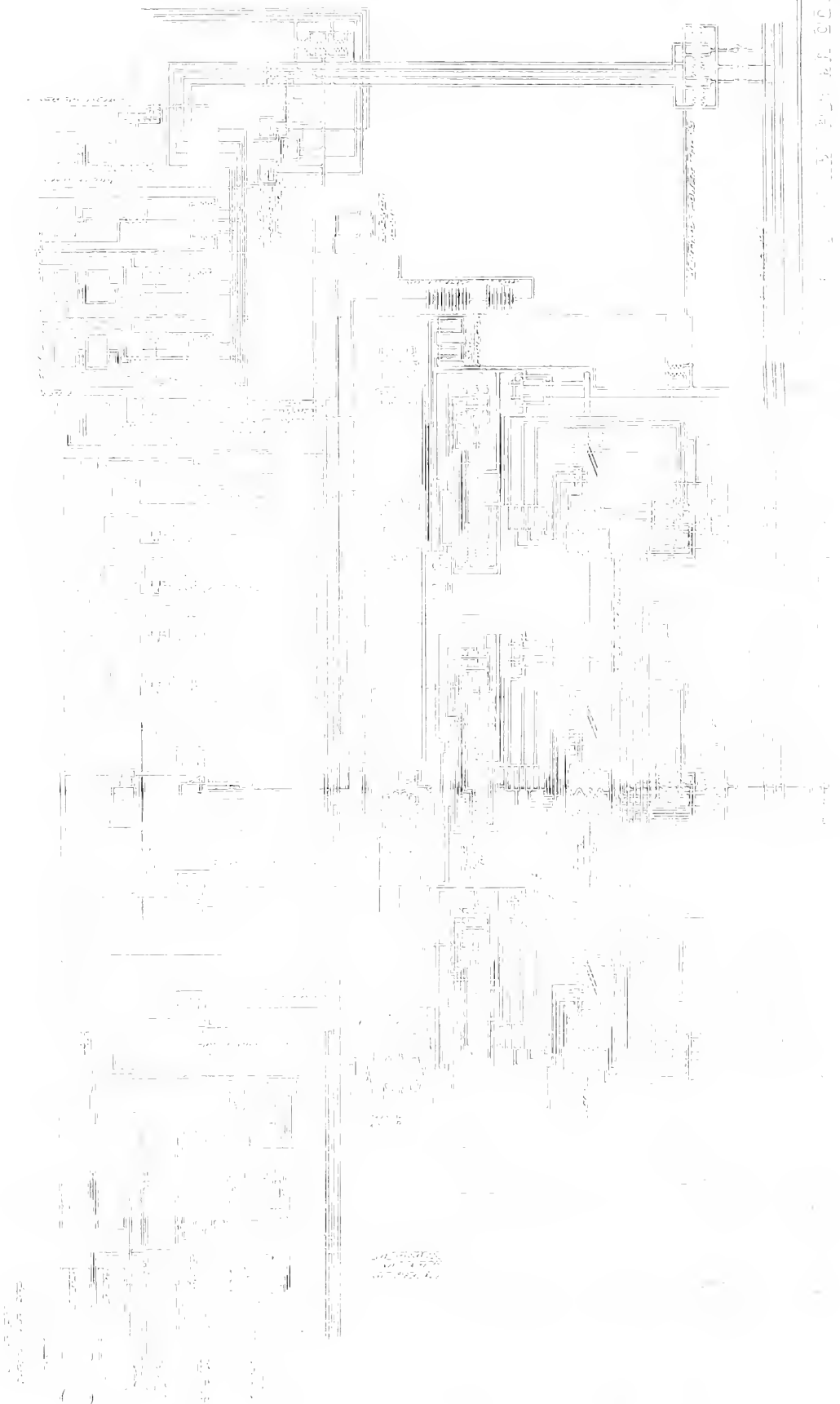
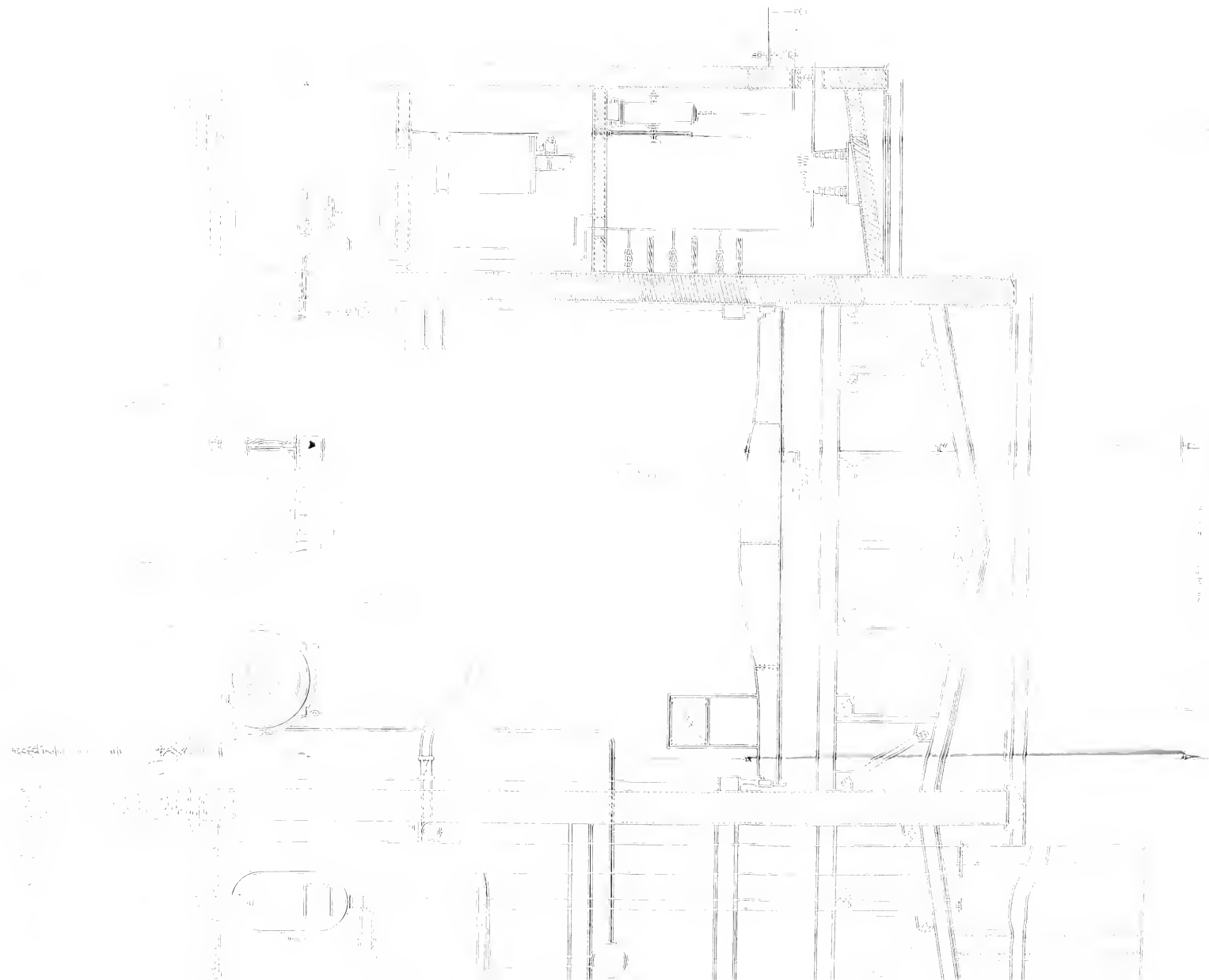


Fig. 1. Plan of the building.

Fig. 2. Section of the building.

Fig. 3. Section of the building.

Fig. 4. Section of the building.



Architectural drawing showing a floor plan of a building. The plan includes a central corridor, several rooms, and a large circular feature on the left. The drawing is oriented with a north arrow pointing towards the top right. The text "Architectural drawing" is visible in the upper right corner.

